The Federal Democratic Republic Of Ethiopia
Ministry of Agriculture and Rural Development

National Rice Research and Development Strategy of Ethiopia

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Acronym

ADLI	Agricultural development led Industrialization
AEZ	Agro-ecological Zone
AISE	Agricultural Inputs Supply Enterprise
ARARI	Amhara Regional Agricultural Research Institute
ARBoARD	Amhara Regional Bureau of Agriculture and Rural Development
ASE	Amhara Seed Enterprise
BoARD	Bureau of Agriculture and Rural Development
CARD	Coalition for Africa Rice Development
COMESA	Common Market for Eastern and Southern Africa
CSA	Central Statistical Agency
DA	Development Agent
EAAPP	East African Agriculture Productivity Program
ECA	Eastern and Central Africa
ECX	Ethiopian Commodity Exchange
EIAR	Ethiopian Institute of Agricultural Research
ESE	Ethiopian Seed Enterprise
FA	Farmer's Association
FREG	Farmers' Research and Extension Group
FSS	Food Security Strategy
GARI	Gambella Agricultural Research Institute
GIS	Geographic Information System
GoE	Government of Ethiopia
HIV	Human Immunodeficiency Virus
IRRI	International Rice Research Institute
IWRM	Integrated Water Resource Management
JICA	Japan International Cooperation Agency
JIRCAS	Japan International Research Center for Agricultural Sciences
KA	Kebele Administration
KARI	Kenyan Agricultural Research Institute
MDGs	Millennium Development Goals
MoARD	Ministry of Agriculture and Rural Development
MoFED	Ministry of Finance and Economic Development
MoWR	Ministry of Water Resources
NARO	National Agricultural Research Organization
NARS	National Agricultural Research System
NERICA	New Rice for Africa
NGO	Non-Government Organization
NRRDSE	National Rice Research and Development Strategy of Ethiopia
OARI	Oromiya Agricultural Research Institute
OPV	Open Pollinated Varieties
OSE	Oromiya Seed Enterprise
PASDEP	A Plan for Accelerated and Sustained Development to end Poverty
R&D	Research and Development

SARI	Southern Agricultural Research Institute
SDPRP	Sustainable Development and Poverty Reduction Program
SG-2000	Sasakawa Global 2000
SNNPR	Southern Nations, Nationalities and Peoples Region
SoRPARI	Somali Pastoral and Agro-pastoral Research Institute
SSA	Sub-Saharan Africa
TARI	Tigray Agricultural Research Institute
WARDA	West African Rice Development Association
WUA	Water Users Association

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Executive Summary

In Ethiopia, among the target commodities that have received due emphasis in promotion of agricultural production, rice is one which is considered as the "Millennium Crop" expected to contribute in ensuring food security in the country. Even though, introduced recently, rice has proven to be a crop that can assure food security in Ethiopia, the 2nd most populous nation in sub-Sahara Africa (SSA) with about 74 million people . The research and development activities on rice, though at limited scale, have shown good productivity level, has also shown the existence of considerably vast suitable ecologies for production along with the possibility of growing, where other food crops do not do well, and compatible with various traditional food recipes like bread, soup, "*enjera*", and local beverages (like "*tela*" and "*areki*"). The country has also a comparative advantage of producing rice due to the availability of huge and cheap labor as the crop is labor intensive.

The potential rice production area in Ethiopia is estimated to be about thirty million hectares. Different scholars who had visited the agricultural potential of the country in different times have confirmed this. They have recommended the introduction of rice to make a difference in ensuring food security in the country. However, rice is a recent introduction in Ethiopia where its breeding and other research components are found at infant stage. Rice breeding research has been started by adaptive trials of introduced varieties, which resulted in the release of some varieties.

The trend in the number of rice producing farmers, area allocated and production shows high increase rate especially since 2006. The number of farmers engaged in rice production has increased from 53 thousand in 2006 to 285 thousand in 2009. Similarly, the area allocated has increased from 19 thousand in 2006 to 156 thousand ha in 2009 along with production increase from 43 thousand tons in 2006 to 500 thousand tons in 2009.

The major challenges and opportunities in the R&D of rice in Ethiopia were identified. The main challenges are related with inputs, agronomic practices, irrigation and water management, pre and post harvest technologies, markets, product utilization, the need for investment, the limited human and institutional capacity, and to some extent policy related matters. On the other hand, the opportunities are related with:

- production potential both under rain-fed and irrigation;
- potential of local rice production in rural poverty reduction and economic growth;

- availability of high yielding and adaptable varieties;
- availability of technology dissemination channels;
- existence of conducive policy environment; and
- the potential of trans-boundary/regional trade.

The present NRRDSE envisages seeing the existing limited area and subsistence-dominated rice sub-sector transformed progressively into commercially profitable and viable production system with the goal of contributing to national food security, increased income and reduced poverty through establishment of a competitive and sustainable rice production and marketing system.

In order to achieve the stated goal, the strategy will follow specific approaches and intervention areas. The approaches to be followed are:

- agro-ecologically based promotion;
- promotion of both small-scale and commercial rice production;
- gender consideration;
- value chain approach promotion; and
- ensuring environmental sustainability.

The priority intervention areas are:

- strengthening the institutional framework and policy development;
- strengthening research, technology dissemination and capacity building;
- promotion of seed production, multiplication and dissemination of certified seed;
- improving fertilizer marketing and distribution, and sustainable soil management;
- promotion of irrigation and investment in water control technologies;
- promotion of the R&D of pre- and post harvest technologies;
- supporting maintenance of agricultural equipment; and
- strengthening agricultural finance and credit.

The NRRDSE targets the production level to increase from about 500 thousand tons in 2009 to about 1.9 million in 2014, and about 4 million tons in 2019. The area allocated for rice will increase from 156 thousand ha in 2009 to 464 thousand and 774 thousand ha in 2014 and 2019, respectively. The assumption in the projection of area and production are:

- Irrigation area for rice will increase on average by 10.2 thousand ha every year in the first five years and about 18 thousand ha /year in the second five years along with productivity increase from 4 t/ha to 5.5 t/ha in 2014 and to 7 t/ha in 2019 due to mainly:
  - rehabilitation and construction of new irrigation facilities;
  - increased involvement of investors in rice production mainly in Gambella, Benishangul Gumuz, Amhara, Somali and Afar regions;
  - expected favorable markets;
  - improved availability of pre & post harvest technologies;
  - better adoption of recommended agronomic and other best practices; and

- high yielding open pollinated (OPV) and hybrid rice varieties will be developed for irrigation

- It is also assumed that rain-fed areas for rice will increases every year with difference for upland and lowland rice. For upland rain-fed rice, the area will increase every year on average by 12 thousand ha in the coming ten years. For lowland rain-fed rice, the area will increase every year on average by about 39 thousand ha in the first five years and by 32 thousand ha in the second five years. Along with this increase in the area, it is assumed that the productivity level will increase from 2.7 to 3.2t/ha for upland rain-fed and from 3.2 to 4 t/ha for lowland in 2014 and to 3.5 t/ha for upland and 5 t/ha for lowland rain-fed in 2019 mainly due to:

  - expected better utilization of Vertisols;
  - improved involvement of commercial rice farms;
  - expected favorable markets;
  - improved availability of pre and post harvest technologies;
  - better adoption of recommended agronomic and other best practices; and
  - high-yielding OPV and hybrid rice varieties will be developed for rain-fed conditions.

The strategy also promotes human capacity building. It targets to have 186 full and part-time researchers, 101 rice research technicians, 25 part-time rice seed technologists and 1326 full and part-time rice extension workers by 2019. The projections of human resources requirements for rice research and development activities are generated based on the assumptions that there will be an increase in:

- the number of research components and/or disciplines to be included in the program,
- the number and quality of research activities in each component and/or discipline addressing rice constraints in different ecosystems,
- the number of research centers dealing in rice, and
- efficient delivery of rice technologies entail adequate, facilitated and motivated human resource.

The NRRDSE will be implemented in phases of short- (1-3 years), medium- (3-5 years), and long-term (> 5 years) taking into consideration the country's decentralized research and development in the agricultural sector.

Short-term strategies would be focusing on:

- variety development and appropriate agronomic practice;
- increasing production and productivity of rice in both rain-fed and irrigation schemes;
- reducing pre and post-harvest production losses;
- increasing availability of agricultural inputs (improved seeds, fertilizers, pesticides and appropriate farm machineries;
- rehabilitation existing irrigation schemes; and
- improvement in post harvest management and marketing.

Medium and long-term strategies would continue complementing the interventions that are implemented during the short-term period and thus be focusing on:

- further development of improved varieties including hybrid once;
- expansion of areas in irrigated together with construction of new irrigation schemes, rain-fed lowland and up-land ecosystems;
- increasing access to farm machinery and pre and post harvest technologies; and
- encouraging investment in medium and large scale processing industries.

Both the short-term and long-term strategies will be linked with capacity building both in human and physical facilities in the research and development aspect of the rice sector. In addition to the formal interventions that will be designed through the yearly planning processes of the MoARD and other partners, specific projects on the different aspects of the rice R&D will be designed and implemented in the short, medium, and long-term period.

The attention given by the Government of Ethiopia (GoE) for the development of the rice sector and existing potentials along with recent tremendous expansion in rice production, confirms the huge potential of sustainability of promoting the sector. In addition, the established partnership between rice producing countries and the Secretariat of the Coalition for Africa Rice Development (CARD) and the Network established between national institutions with international institutions associated with rice development (EIAR, KARI, NARO, Africa Rice Center, IRRI etc) would ensure regular supply of new technologies in sustainable manner. In this regard, further strengthening the started public interventions along with the strengthened partnerships and networks is a key in promoting the sustainability and competitiveness of the sector.

1 Background

1.1 Introduction

Although Ethiopia is situated in the tropical zone, its wide range of altitude, from below sea level to over 3000m above sea level, gives it a wide range of climate from humid tropics to alpine climates, where most types of crops could successfully be grown. In addition, the country has 12 major river basins, 11 lakes, and over 12 major swamps. The total mean annual flow from all the 12 river basins is estimated to be 122 billion cubic meters and the ground water potential is estimated at 2.6 billion cubic meters. These water resources can potentially be used for irrigation. Ethiopia has also one of the largest livestock inventories in Africa, including more than 47.6 million heads of cattle, 48 million small ruminants, one million camels, 7.7 million equines and 40 million chickens (MoARD and CSA, 2008), with livestock ownership currently contributing to the livelihoods of an estimated 80 percent of the rural population along with livestock.

With this potential though, the country's history is punctuated by food insecurity and famine due to climatic variability and the poor performance of the agricultural sector. Realizing this problem, the government has been implementing Agricultural Development Led Industrialization (ADLI) strategy. The current five-year development Plan (PASDEP, 2006) of the government gives recognition and focus to commercialization as the next step of agricultural development. It envisages diversification and specialization of crop and livestock production by farmers to improve allocative efficiency, and intensification of resource use to improve technical efficiency.

Among the target commodities that have received due emphasis in promotion of agricultural production, rice is one which is considered as the "Millennium crop" expected to contribute in ensuring food security in the country. Even though, introduced recently, rice has proven to be a crop that can assure food security in Ethiopia, the 2nd most populous nation in sub-Sahara Africa (SSA) with about 74 million people in 2007 (CSA, 2008). R&D activities so far undertaken on rice in the country, have shown good productivity level, has also shown the existence of considerably vast suitable ecologies for production along with the possibility of growing, where other food crops do not do well, and compatible with various traditional food recipes like bread, soup, "*enjera*", and local beverages (like "*tela*" and "*areki*"). The country has also a comparative advantage of producing rice due to the availability of huge and cheap rural labor as the crop is labor intensive.

The potential rain-fed rice production area in Ethiopia is estimated to be about thirty million hectares estimated based on GIS techniques and rice agro-ecological

requirement. Rice is a recent introduction in Ethiopia where its breeding and other research components are found at infant stage. Rice breeding research has been started by adaptive trials of introduced varieties, which resulted in the release of some varieties.

Farmers as well as private investors who frequently request for improved varieties for different ecosystems recognize the importance of rice as a food security crop, source of income and employment opportunity due to its relative high productivity as compared to other cereals.

Cognizant of the stated importance of rice and existing potential for its production, a national steering committee was established to promote the R&D activities on rice in the country. The Technical Committee composed of experts from different institutions shouldered the responsibility to develop the National Rice Research and Development Strategy of Ethiopia (NRRDSE) to make sure that the country will benefit from the crop. The committee generated the required information for identification and prioritization of relevant opportunities and constraints through review of literature, discussion with key informants (producers, traders, processors, experts, and consumers), and field visits to major rice production areas including Gura Ferda in Bench Maji Zone of SNNPR, Chewaka in Illu Aba Bora Zone of Oromiya, Fogera in Amhara Region, Gode in Somali region, Pawe in Benishangul Gumuz, Abobo in Gambella and Tsegede in Tigray.

This strategy was presented to wider stakeholders and beneficiaries at a workshop for improvement and to the National Rice R&D Steering Committee for approval.

1.2 The global rice sector

Rice is the most important food crop of about half of the human race. It is the leading and one of the oldest cereal crops of southeast Asia, which is a thickly populated region of the world. Rice is the only major crop that can be grown in the standing waters of vast areas of flat, low-lying tropical soils. It is uniquely adapted for growth in submerged soils (Daniel and Thulasidas, 1993). Rice is grown in the tropical and subtropical regions of most continents. It grows from the equator to latitude 53^0 N (China) and 40^0 S. Rice can grow well from sea level to 3000 m such as in the Himalayas. Over 90% of the total rice crop is produced in South Asia and East Asia. In area and production, China is the leading country in the world. Africa accounts for 2% of the world production. Rice is cultivated under widely differing conditions because of the great cultivar diversity. The major limiting factor for its growth is not climate but water supply. Because of its heat loving characteristics, rice is a crop most suitable for the tropics and subtropics, although it can be grown during the summer in warm temperate regions.

The global rice cultivation is estimated at 150 million ha with annual production averaging 500 million metric tons (Tsuboi, 2004). Rice represents 29 % of the total output of grain crops worldwide (Xu et al., 2003). In terms of yield recorded worldwide, 13.2 t/ha in Japan, 11 t/ha Philippines, and 17.8 t/ha in India (Yoshida, 1983). If these yields are compared with the world average of about 3.8 tones/ha, it is evident that there is a lot of potential to improve rice yields worldwide. Development of rice, therefore, presents an opportunity to reduce the number of food insecure people that stand at 860 million by half by 2015 (One of the MDG goals).

1.3 Africa's rice sector

Rice is also becoming increasingly popular in Africa with about 16 million metric tons of annual consumption and 14 million tons of production, creating a deficit of 2 million metric tons, which is filled by imports. For instance, the total value of rice imports by West African countries is estimated at 1.4 billion USD per year (Somado *et al*., 2008). System of rice culture in Africa is generally classified into five based on the growing ecosystems.

- dry land or upland rice is grown on naturally drained soils where the water table always remains below the rice roots. The moisture supply is entirely rainfall;
- hydromorphic (rain-fed lowland) rice is grown on soils where the roots are periodically saturated by fluctuating water table in addition to rainfall;
- mangrove swamp rice (tidal swamp rice) is grown in swamps along coastal areas with tidal intrusion;
- inland swamp rice (rain-fed medium to deep-waterlogged rice) is grown on flat or V-shaped valley bottoms and floods, which sometimes lead to floating conditions; and
- paddy rice (irrigated rice) is grown on banded paddies, either under rain-fed or irrigated condition.

Currently, rice is grown in over 75% of the African countries with a total population of 800 million people. Africa has become a big player in international rice markets, accounting for 32% of global imports in 2006. The potential for growth in African rice sector is enormous. A rapid increase in the area under rice, irrigated as well as rain-fed is necessary; in particular, the development of new irrigated rice schemes is vital. Only 17% of the rice area in Africa is irrigated. Asia, in contrast, has 57% of the rice area under irrigation, but has little or no room for further expansion (Somado *et al*., 2008). If proper interventions are in place, the existing potentials of Africa can enable to produce more than the level of consumption with a potential of export.

1.4 Ethiopia's rice sector

Ethiopia's elevation, terrain, and climate make its agricultural system unique, allowing for multi-crop cultivation in small fragmented areas. There is vast land and water resources still waiting to be developed. The hot to warm moist climates are potentially suitable for rice culture as they fulfill all the requirements of the crop. Hence, the time may not be too far for Ethiopia to be one of the major producers of rice in the world (Shahi, 1985).

Research on rice was started informally by Tana Beles Project and by the Koreans who were in Ethiopia for a different mission. These bodies developed and used some promising rice varieties in the western and northern parts of Ethiopia. At present, Pawe, Adet, Gode, and Gambella Research Centers are putting rice research on a strong footing. The Crops Research Directorate of EIAR has recognized the importance of giving due attention to nationally significant crops such as rice, sugarcane, spices and certain root crops.

The Tana Beles Project at Pawe and the Koreans in the Fogera Plain identified promising rice varieties suitable for small-scale and large-scale production. Pawe Research Center released M-55 as Pawe-1 in 1999 and the Amhara Regional Bureau of Agriculture and Rural Development (ARBoARD) released three improved rice varieties (IAC-164, IREM 194, and IRAT 209) in 2000.

In 2005, the extension Directorate of MOARD developed the existing extension package in collaboration with JICA and SG 2000. It has been tried to incorporate possible available technologies and improved practices, rice food recipe and extension service approach in the package. As rice is a new crop and has different suitable ecosystem in the country, updating the package periodically with available new technologies and improved practices requires short and medium term duration. Currently, the extension department is revising the package incorporating recently released upland NERICA varieties. Moreover, developing area specific and rice ecosystem based extension package is going to be effective according to the intervention and implementation strategy in this document.

Today rice is produced mainly by small-scale farmers in many parts of the country, but also with large-scale farmers in few places. Total milled rice production in 2009 was estimated at 323,916 metric tons. Total current rice consumption is estimated at 353,998 tons with estimated annual average import of 21,724 tons over the last ten years. Ethiopia adopted NERICA varieties such as NERICA-1, 2, 3, 4 and Suparica-1 varieties in addition to the local varieties such as X-Jigna and others. Due to the introduction of upland and irrigated rice varieties in the country, rice farming has grown from 19,500 farmers in 2005 to over 284,868 in 2009. Currently, twelve upland/lowland NERICAs, Sativa types, and three irrigated rice varieties are released in Ethiopia during 1999 and 2007.

In Ethiopia, tef, maize, wheat and sorghum are among the cereal crops used to be the staple food crops and target of most of the food security programs. However, the recent trends in the area and production of rice along with its high compatibility in the traditional consumption habits shows that rice is becoming one of the staple foods and important for ensuring household food security. The rice expansion is associated with the possibility of producing it in marginal areas mainly in the abundant Vertisols, the relatively high level of productivity achieved as compared to the main staple crop, tef, and the possibility of using in the traditional "*enjera*" making.

2. Policies, Production, and Consumption Characteristics

2.1. Status of rice in national agricultural policies

Agriculture is the main stay of Ethiopian economy, contributing 43% share in the gross domestic product (GDP) and about 83.3% of the population is engaged in agriculture; about 70% of the Ethiopia's industry is engaged in processing farm products (MoFED, 2007, 2009). From the total area in the country, 67% is estimated to be suitable for agricultural purposes.

The bulk of agricultural output comes from 13.3 million small-scale subsistence households, each owning, on average, about 0.93 ha of land and produces a number of different food and cash crops besides herding livestock (CSA, 2008).

Agricultural farming is still predominantly rain-fed, limited market orientation, and based on rudimentary technologies and environmentally unsound practices. Resultantly, the country's agricultural products are often of low volumes, poor quality and are costly to assemble for sustainable market supply, which affects the profitability of farmer's enterprises.

Cognizant of the above-mentioned structural problems of the country's agricultural sector, the GoE's has in place agricultural development policies and strategies in line with the overall strategy framework of ADLI formulated in 1991. ADLI places very high priority on accelerating agricultural growth and achieving food security. Agriculture is also a main focus of the GoE's poverty reduction strategy, which includes the Sustainable Development and Poverty Reduction Program (SDPRP) approved in 2002, the 2004 Food Security Strategy (FSS), and, the 2006 Plan for Accelerated and Sustained Development to End Poverty (PASDEP) (MoFED 2002, 2006). Since the 2006 PASDEP will end in June 2010, the new PASDEP is expected to incorporate the targets of this strategic document.

During the 1990s, the GoE pursued its ADLI strategy by enacting a series of policies seeking to generate:

- a supportive macroeconomic framework;
- liberalized markets for agricultural products; and
- a strong extension- and credit-led push for intensification of food staples production through the use of modern inputs, especially seed and fertilizer.

These early reforms focused on cereals and provided a much-needed boost to agricultural production. In this regard, rice, which is considered as one of the major cereal crops for improved production and productivity of the agricultural sector, is expected to play an important role in achieving the set strategic policy objectives.

2.2. National rice production trends

The development aspect in promoting rice production is also limited to certain areas. However, there is an increasing trend in both area and production of the crop since 2006. The trend in the number of rice producing farmers, area allocated and production by region and *wereda* is summarized in Table 1.

Table 1 Paddy rice production, area and number of participating farmers by *wereda* and region (2006 – 2009)

Region	*Wereda* /site	2006			2007			2008			2009		
		No. of farmers	Size (ha)	Production (ton)	No. of farmers	Size (ha)	Production (ton)	No. of farmers	Size (ha)	Production (ton)	No. of farmers	Size (ha)	Production (ton)
Amhara	Metema	351	117	330	3,840	1,280	3,840	9,500	2,500	9,250	10,275	7,200	26,325
	Fogera	23,616	7,872	19680	46,800	15,600	39,000	116,000	29,000	81,200	115,000	30,000	94,866
	Libo-kemkem	12,567	4,189	8378	27,600	9,200	18,400	48,800	12,200	28,060	52,000	15,500	38,292
	Dera	8,148	2,716	5432	15,000	5,000	10,000	29,380	7,345	16,159	31,230	11,450	28,287
	Sekela	1,338	446	892	2,700	900	1,800	6,400	1,600	4,480	7,400	2,780	7,692
	Achefer	208	52	104	360	120	240	1,360	340	986	2,470	1,500	4,299
Sub-total-1		46,228	15,392	34816	96,300	32,100	73,280	211,440	52,985	140,135	218,375	68,430	199,761
Tigray	L/koraro							2,880	720	1,800	3,900	1,800	4,646
	Tsegede							492	217	651	870	1,200	3,716
	Tselemt							228	334	835	970	1,000	2,581
	Welqayit										695	650	2,013
	Humera										420	500	1,549
Sub-total-2								3,600	1,271	3,286	6,855	5,150	14,505
Benshangul Gumuz	Bambasi							688	172	516	2,200	7,350	17,877
	Kurmuk							786	190	665	685	1,800	5,108
	Pawe										600	450	8,026
	Assosa										345	480	1,245
Sub-total-3								1,474	362	1,181	3,830	10,080	32,256
Oromiya	Chewaqa	740	185	555	5,400	1,800	6,300	10,248	2,928	11,126	10,500	5,430	19,373
	Dedessa	859	359	1077	2,085	695	2,085	4,740	1,185	3,555	5,800	3,700	10,422
	Borecha	291	77	193	960	320	800	3,000	750	2,850	3,050	1,300	4,638
	Bedelle	126	60	120	345	115	230	1,520	380	1,064	2,765	1,285	3,378
	Darimu	45	2	4	75	25	50	248	62	143	250	370	868
	Shebe							2,280	570	1,938	2,700	855	2,729
Sub-total-4		2,061	683	1949	8,865	2,955	9,465	22,036	5,875	20,676	25,065	12,940	41,408
Somali	Gode	70	15	45	5,940	1,980	5,940	1,734	3,120	10,920	2,600	7,530	27,921

Region	*Wereda* /site		2006		2007			2008			2009		
		No. of farmers	Size (ha)	Productio n (ton)	No. of farmers	Size (ha)	Production (ton)	No. of farmers	Size (ha)	Production (ton)	No. of farmers	Size (ha)	Production (ton)
	Kelafo	80	13	39	7,650	2,550	7,875	3,420	6,800	27,200	5,700	9,250	39,199
Sub-total-5		150	28	84	13,590	4,530	13,815	5,154	9,920	38,120	8,300	16,780	67,120
SNNPR	Yeki	150	75	150	450	150	300	1,020	255	765	1,050	420	969
	Boreda	100	50	100	336	112	224	1,000	250	750	1,045	487	1,123
	Gura-ferda	4,515	2,257	5643	30,000	10,000	25,000	12,857	18,000	75,600	19,450	27,500	88,802
	Gimbo	68	34	68	288	96	192	804	201	563	850	530	1,182
	Shashego	12	3	6	18	6	12	24	6	16			
	Misha	18	4.5	9	21	7	14	36	9	29	48	39	99
	Debub Ari											180	387
Sub-total-6		4,863	2,424	5,976	31,113	10,371	25,742	15,741	18,721	77,723	22,443	29,156	92,562
Gambella	Gambella Zuriya							240	479	1,533		5,900	21,807
	Abobo							417	835	2,923		7,450	28,913
Sub-total-7								657	1,314	4,456	0	13,350	50,720
Grand total (1-7)		53,302	18,527	42,825	149,868	49,956	122,302	260,102	90,448	285,577	284,868	155,886	498,332

Source: SG 2000, 2009 (unpublished)
Note: estimates are based on the reports available. Therefore, there may be other weredas in each region that produces rice not included

The stated increasing trend in area allocation and production of rice was achieved through the joint effort of both different governmental and nongovernmental organizations. Tigray, Benishangul, and Gambella are regions that entered into rice production in later years; however, these are regions with considerable potential in the future.

2.3. Consumers' preferences and demand projections

Ethiopian rice consumers are of two types i.e. rural consumers in rice production areas, who consume locally produced rice and urban consumers who consume mainly imported rice. In most of the production areas, rice is consumed through traditional ways of food preparation mainly mixing with "*tef*" or sole to make "*enjera*" and mixing with wheat or sole to make bread. Commonly, local liquor called "*areki*" and "*tela*" are also made of rice. In urban areas, the imported rice that is commonly aromatic to non-aromatic and non-sticky after cooking is preferred. Along with the increased level of production, there is increased volume of rice import. The trend is presented in Figure 1

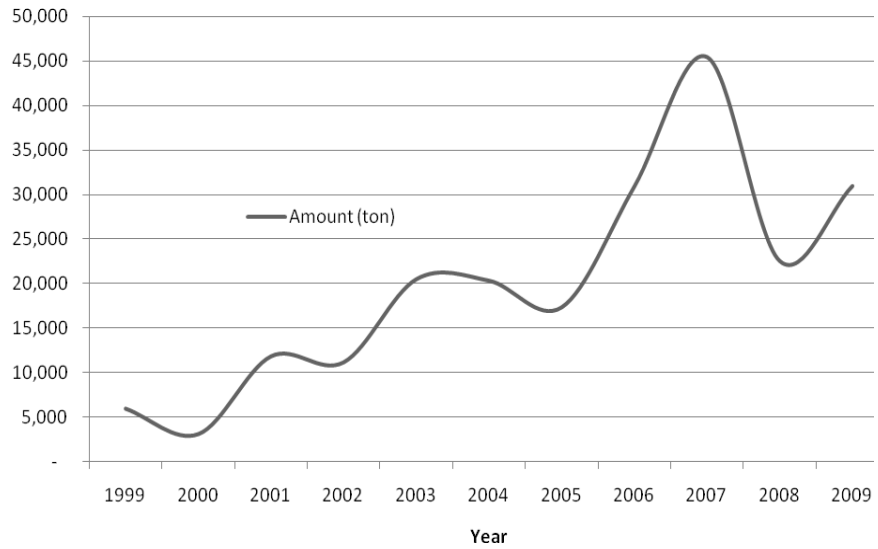

Figure 1 Trends in the amount of commercial rice import (1999 – 2009)
Source: Ethiopian Customs and Revenue Agency, 2009

It is assumed that if the target increase in the level of production continues, the country will be able to substitute imports in 5 years time and will export specifically from the large-scale private commercial farms from Gambella (Table 2).

Table 2 Milled rice production, consumption and importation

Year	Total Production milled rice (t)	Population (million)	Consumption per head and annum (kg)	Total Consumption (t)	Rice Imports (t)	Export (t)
2008	185,625	73,918,505	3	211,292	25,667	
2009	323,916	75,840,386	5	353,998	30,082	
2014	1,227,060	85,699,636	12	1,016,382		210,678
2019	2,572,910	96,840,588	22	2,086,353		486,558

Source: Ethiopian Customs and Revenue Agency for imports, SG-2000, 2009 (Unpublished); CSA, 2008

In addition, for sustainable increase in the demand for domestic rice, there will be a need to promote

- competitive rice varieties in terms of test and appearance;
- improved post harvest handling,
- promotion of rice consumption through advertisement, and development of recipes and dishes; and
- promotion of competitive marketing system (improving availability in different forms and packages, standards, pricing, etc).

2.4. Typology and number of farmers, processors, and traders

Rice farmers

Majority of rice farmers are smallholders, who produce rice for home consumption and sell surplus directly to customer or processors. As indicated in Table 1, there are 284,868 smallholders engaged in rice production with average land size of 0.5 ha per household in 2009 production season. The number of farmers engaged in rice production is increasing from time to time. According to estimates, there were 53,302 farmers in the 2006 production season, which has increased to 149,868 farmers in 2007, 260,102 farmers in 2008 and to 284,268 in 2009 production seasons. Farmers normally sell their rice at farm site to local traders. About 30 % of the farmers sell immediately after harvest (70% use storing as a marketing strategy). There is also an emerging trend in rice commercial farming mainly in Gambella, SNNPR, Afar and Somali Regional States.

Processors (millers)

Since the sector is not well developed, there are very few modern processors with dehu1lling facilities, which also incur losses. Farmers normally thresh the rice using oxen power and human labor and bring to processors, which are commonly located in production areas. Farmers either sell to the processors or get the service from them. There is wide spread report that considerable loss of produce due to poor processing, which is estimated to reach up 50%.

Rice traders

There are paddy and milled rice traders (wholesalers and retailers) that are scattered all over the country. Most of the milled rice is handled by importing traders. The paddy traders are found in production areas with traditional way of handling the product. Retailers are supermarkets and small kiosks scattered all over the country.

2.5. Gender dimension in production, processing and trading

In Ethiopia, all farm household members are commonly engaged in farm activities. Since rice is a labor-intensive crop, the need for household labor is very high. Women are also engaged in most of the farm operations in addition to the load they shoulder in managing the household mainly taking care of children. Women play a major role in rice production in the country, as they are involved in all aspects of rice value chain particularly planting, weeding, bird scaring, harvesting, processing and trading. It is observed that men are mostly involved in the land preparation. Both men and women are engaged in rice harvesting and threshing. Therefore, the introduction of labor saving technologies in the rice farm operations has paramount importance in addressing gender issues.

2.6. Comparative advantage of domestic rice production

The comparative advantages of domestic production of rice in Ethiopia are in the following:

- the existence of research support with good linkage to international research institutes like IRRI and Africa Rice Centre, JIRCAS, which have adapted and released suitable rice varieties with required agronomic and food qualities;
- the existence of huge production potential both under rain-fed and irrigation conditions;
- domestically produced rice is of acceptable types and fulfills requirements of the domestic as well as the international markets;
- the existence of huge competitiveness mainly because of the existing cheap labor, which can improve the competitiveness of Ethiopian rice in the international markets and the existing huge post-harvest loss (about 50%), which can be improved by using cost effective production technologies and installation of milling and processing facilities close to the production areas;

- the existence of considerably high domestic demand, where attempts are made to satisfy through imports; and
- possibility of linking to microenterprises in the value addition, maintenance and also petty trade

3. Challenges and Opportunities

3.1. Challenges

3.1.1. Input related

The major constraints in the area of inputs for rice production are summarized in Table 3. The major constraints prioritized were poor access to improved rice varieties, which is caused mainly due to two interlinked problems. The first being the limited number of high yielding varieties especially for irrigated rice, including the field management practices of released from the research system and the second is the limited participation of seed growers (both the public and private companies) in producing and marketing rice seed. This is in line with the limited emphasis given to rice research that the released varieties in the country are few in number and do not address all the rice growing ecosystems, the demand of the producers as well as the consumers and the array of biophysical stresses. The Ethiopian Seed Enterprise (ESE), which is the major seed producer in the country, has only one farm suitable for rice seed multiplication at Chagni in Amhara region, which can serve areas that are Striga affected. However, the ESE does not have any suitable farm for rice seed multiplication for Striga free areas of the country.

Table 3. Prioritized rice production inputs constraints

Constraints	Rank
Access to improved varieties	1
Access and use of post-harvest equipment	2
Access and use of pesticides	3
Access and use of pre-harvest equipment	4
Financial shortage	5
Labor shortage during pick farm operation season	6
Access and use of chemical fertilizer	7

The second major constraint reported was related with the poor access and use of modern post-harvest techniques and equipment. The current techniques employed are traditional that there is reportedly considerable post harvest loses in addition to the low product quality.

Even though, the level of pest and disease incidence on rice in most of the production areas is not that serious, it was found that grass weeds and insects are found to be the third major constraints, which can be tackled if appropriate

pesticides are available. Thus, the pesticide questions related to what, when, at what rate, for which pest to use need to be addressed.

Rice in most of the production areas is produced under wet soil moisture condition like in the Fogera plain, even though the production is now expanding into drier areas. This condition causes both land preparation and cultivation work to be much drudgery. Thus, there will be a need to develop and disseminate appropriate pre-harvest equipment with associated improved techniques.

In areas where chemical inputs like fertilizer use for rice is common like in Chewaka area, there is a need to improve access to credit to improve the use of these inputs. However, because the soil fertility in the current production area is still high, farmers do not yet accept the use of chemical fertilize on rice fields. Labor shortage has been also identified as a constraint specifically during weeding time.

3.1.2. Agronomy related

The major agronomic constraints in rice production are weeds, insects, and diseases, and lack of their control methods. Poor land preparation techniques are reported to be the third rice production constraint. The method and date of planting taking into consideration the rainfall patterns, soil type, and seed rate were reported as a constraint. The type, rate and date of fertilizer application were reported the least constraints, mainly due to the limited utilization of chemical fertilizer under the current production system (Table 4).

Table 4. Prioritized constraints of rice agronomy

Constraints	Rank
Weed and weed control method	1
Insect disease and birds and their control methods	2
Poor land preparation technique	3
Method and date of planting	4
Seed rate	5
Type, rate and date of fertilizer application	6

3.1.3. Irrigation and water management related

Despite of the potential for rice production in Ethiopia, there exist challenges in irrigated rice development which includes:

- low level of attention for rehabilitation of existing irrigation schemes and resulting insufficient water retention due to siltation;
- shortage of improved irrigated rice varieties;
- salinity and drainage problems;

- limited skilled human resources in the field of irrigation technicians and irrigation water management;
- lack of strong and clear guideline, extension system and integration among different disciplines and institutions in considering rice as irrigated crop in most existing irrigation schemes;
- low irrigation efficiencies (storage and conveyance, etc) and the high cost of pump irrigation for repair and maintenance and fuel have resulted considerable constraint to expansion of irrigated rice production;
- huge investment requirement in promoting new irrigation schemes; and
- social and environmental constraints: some of the negative social and environmental impacts of irrigation could cause conflict among users due to over abstraction of water and inefficient use by irrigation schemes; prevalence of water borne diseases such as malaria, and others and increased salinity.

The prioritized constraints in promoting irrigated rice are summarized in

Table 5. These are related with lack of improved technology and associated extension services, limited irrigation are due to both limited rehabilitation of the existing ones and limited construction of new facilities along with human capacity.

Table 5 Prioritized constraints of irrigation and water management

Constraints	Rank
Lack of improved variety for irrigated rice	1
Poor extension service	2
Limited emphasis on rehabilitation of existing irrigation schemes	3
Limited expansion and construction of new irrigation schemes	4
Limited human resource capacity (esp. irrigation agronomist and technician)	5
Salinity and drainage problems	6

3.1.4. Pre-and post-harvest mechanization technologies

Appropriate soil tillage machinery/ equipment desired in the conditions of the different AEZs, suitable and adequate power supply for different farm operations; presence of equipment leasing and maintenance service providers and availability of adequate supply of spare parts, are important requirement for the successful farm operation in increasing rice production and to remove drudgery from farm operations. For instance, the area around Gambella and Pawe is poorly drained Vertisols, where farmers encounter the difficulties in preparing hard soil prior to the onset of the rainy season and/or the sticky nature of the wet soil after onset of the rainy season, which does not permit timely

sowing and management of crop with draft animal. Tsetse fly and malaria are also the other problems in promoting mechanization. Alternative power source to animals is essential for efficient cultivation of the land of this area.

Consistent with the priority of rice production input constraints, post harvest handling in terms of availability and access of equipments are reported to be the major constraints in rice production (Table 5). Even though, producers reported that they do not store rice due to high market demand immediately after harvest, limited of modern storage facilities was reported to be the second major constraint.

Rice husking and milling is accomplished mostly by using local flourmills. Thus, recovery of good quality milled rice is very low due to excessive grain breakage. Although there are few rice mills in Fogera and Gura Ferda *weredas*, the availability of efficient dehulling and milling equipments are reported to be the major constraints in rice production (Table 6). Produce is stored in jute bags in their home or in traditional storage bins. Hence, these storage practices are incapable of providing and maintaining the storage requirements of the produces for long-term storage, grain losses are high and the lack of modern storage facilities was reported to be the second major constraint. Harvesting and threshing is done manually and by trampling of animals.

Table 6 Prioritized constraints of pre- and post-harvest handling of rice

Constraints	Rank
Limited availability and poor knowledge about threshing/dehulling and milling equipment	1
Lack of storage facilities	2
Limited availability and poor knowledge about harvesting tools	3
Poor harvest pilling and transportation	4
Storage pest problem	5

Availability, access, and knowledge about harvesting tools along with delayed harvesting and product shattering were reported the third most important constraints during this time were reported as third constraint. This was justified due to the shattering of rice grains during harvesting while using the traditional harvesting tools like sickles. The same was reported related to piling and transporting of the harvested rice. Storage pest problem was the least prioritized constraint, which is mainly because currently farmers do not store rice and even if they do it, is stored as whole grain.

3.1.5. Market related

Table 7 summarizes the prioritized constraints in the rice marketing and the major constraints are related with the poor knowledge of the producers and other market actors about rice product quality, limited access to rice market

information, and limited of group marketing options. The other constraints are limited use of storage as marketing strategy, excessive intermediaries, and price seasonality. Limited market and small number of buyers were prioritized to be the least important constraints in rice marketing. Of course, the listed prioritized constraints are mainly related with the limited market infrastructure available.

Table 7. Prioritized constrains in rice marketing

Constraints	Rank
Limited knowledge about grading	1
Poor access to market information	2
Limited of group marketing options (coop/unions)	3
Limited use of storage as marketing strategy	4
Excessive intermediaries	5
High price seasonality	6
Limited number of buyers/considerable price dictation	7
Limited access to market	8

3.1.6. Utilization

In general, from rice grain different dishes can be prepared, the straw can be used as feed, and the husk can be used both for feed and fuel. However, the utilization aspect is very weak mainly due to the recent introduction of the rice in the country. Even though, different ways of food preparation from rice are reported in the rice producing areas like enjera and local dinks, the major constraints reported in this aspect was the limited types and ways of food preparation from rice. Similarly, poor knowledge about the use of the husk and the straw for feed and fuel are also reported as constraint. Consumption habits were reported to be the least constraints (Table 8).

Table 8 Prioritized constraints in the utilization of rice and its byproducts

Constraints	Rank
Limited types of dishes	1
Poor knowledge about the use of husk as fuel source	2
Poor knowledge about the use of straw as feed	3
Poor knowledge about the use of husk as feed	4
Poor consumption habit	5

3.1.7. Investment

Considerable interest in large-scale commercial production of rice is reported to exist in all potential areas of the country and there are already large-scale commercial producers in some of these areas. In this regard, there is a need to have a differentiated approach depending up on the local population in the

investment areas. In addition, creating a production and marketing system that will also engage small-scale rice producers is a challenge. Experiences from Asia in terms of empowering the value chain where small-scale rice producers are equally empowered shows the importance of promoting commercial production of rice along with out-grower and contract-farming schemes. Moreover, much more investment is required in the areas of rice value addition especially dehulling, polishing, grading, and packing as a synergetic intervention.

3.1.8. Human and institutional capacity

3.1.8.1. Human capacity

The number of trained scientists working on rice has increased over the years, even though; the total number is too small. Adet Research Center of Amhara Regional Agricultural Research Institute coordinates the rice research program in Ethiopia. EIAR and other regional research institutes are also engaged in the research. Currently, the total number of researchers engaged in rice research is 6 fulltime and 17 part-time. With increasing area of production and the vast production constraints, building the human capacity is one of the challenges that need due attention both at regional and federal level.

Currently, there is a limited human capacity in seed multiplication and quality control specialized in rice both at the federal and regional level (ESE, ASE, OSE, Animal and Plant Health and Quarantine Directorate of MoARD and BoARD).

The transfer of technology is of fundamental importance to the future of the rice sector. For improved provision of agricultural extension services, MoARD has in place three extension/development agents (DAs) at each Kebele Administration (KA) and currently, there are over 50,000 development agents placed in KA all over the country, which is a good opportunity to promote rice production technologies and linking rice produced to markets. However, it should be noted that these DAs are not well equipped with required facilities to do proper extension work, which is really a challenge that needs due attention. Especially, facilities related with DA's mobility, timely training, and access to required demonstration facilities are important challenges. When the participation of the private sector along the rice value chain gets improved, adequate attention will be given in building their human capacity accordingly.

3.1.8.2. Institutional capacity

EIAR along with other NARS members have a modest research capacity for adaptation of rice technologies. The different research institutes engaged in the research are EIAR (Werer, Asosa, Pawe, Jimma, and Melkassa Research Centers); ARARI (Adet, Sirinka, Gonder and Bahir Dar Agricultural Mechanization Research Centers); SoRPARI (Gode Research Center); TARI (Mekelle, Aksum, and Humera Research Center); OARI (Bako Research

Center); SARI (Bonga and Areka Research Center); and GARI (Abobo and Gambella Research Center). However, the institutional capacity in terms of having required facilities is very limited in all of the research centers.

The institution capacity of seed production in the country is also very limited. The ESE is the major seed producer but it is constrained with lack of farm suitable for production of rice for Striga free areas/regions. Currently, it is multiplying rice seed at Chagni, which can be distributed only for Striga affected areas. The same is true with the regional seed enterprises (OSE and ASE).

In the technology transfer, there is relatively good institutional capacity at both Federal and Regional level along with other development partners like SG-2000 and JICA. However, still there is a challenge in strengthening institutional linkage and coordination among all partners including public, private and NGOs and donors.

3.1.8.3. Socio-Cultural Issues

Rice is a very labor-intensive crop, which requires the engagement of all household members. In communities where women and children are engaged in rice production as a major source of livelihood, it may be the case that it will divert them from activities like education for children and household management for women unless properly planned and also appropriate labor saving technologies are introduced.

The other dimension of the socio-cultural challenge is the poor tradition of rice in the food preparation and consumption in many rural areas even though, this may not be the case in urban areas. Thus, there is a need to introduce different dishes and preparation methods to rural communities. Similarly, the considerable incidence of malaria and trypanosomaisis in the major rice production areas along with migrant labor, the issue of health and HIV are real challenges that need due consideration as one of the socio-cultural dimension.

3.1.8.4. Trans boundary/regional issues

Even though, the trans-boundary trade in rice in the region is at its infant stage, there is an informal cross-border trade of rice with most of the neighboring countries, which is a challenge for formal trade and exchange of germplasm. In addition, this informal cross-border trade or exchange will be a challenge for the formal certification and trade of certified rice seed.

3.1.9. Policy related

Overall, there are favorable economy-wide and agriculture sector specific policy measures in place, which give a framework and incentive for all actors who are or will be engaged in the rice sector. However, there are still policies and institutional challenges related to further strengthening and designing

interventions and implementation related to enhancing producer price support mechanism in terms of:

- market facilitation; and
- improving access to micro and rural credit facilities to make credit accessible; and affordable to farmers, processors and traders; and developing and harmonization of national trade policies along with the east African Community.

3.2. Opportunities

3.2.1. Production potential for rain-fed and irrigated agriculture

The production potential for rain-fed rice in the country was assessed using GIS techniques. The parameters considered were rainfall, slope, soil texture, altitude, and temperature. The distribution of the land suitable for rice production is presented in Table 9. As summarized in Table 9, there is about thirty million ha (5.6 million ha highly suitable and about 25 million suitable) for rice production in the country. However, it should be noted that these estimates are based on only the above stated parameters without field level verification.

Table 9. Size of potential area by level of production potential for rain-fed rice (ha)

Region	Highly suitable	Suitable	Moderately suitable	Total
Tigray	-	1,278,245	935,565	2,213,810
Afar	2,318	147,084	124,158	273,560
Amhara	483,839	5,289,945	2,229,180	8,002,964
Benishangul Gumuz	2,053,332	2,817,944	53,235	4,924,511
Somali	-	69,893	375,222	445,115
Oromiya	2,051,787	8,082,388	3,993,068	14,127,243
Dire Dawa	-	601	38,553	39,154
Gambela	373,848	2,752,345	38,037	3,164,230
SNNPRR	625,771	4,472,184	1,065,648	6,163,603
Total	5,590,895	24,910,629	8,852,666	39,354,190

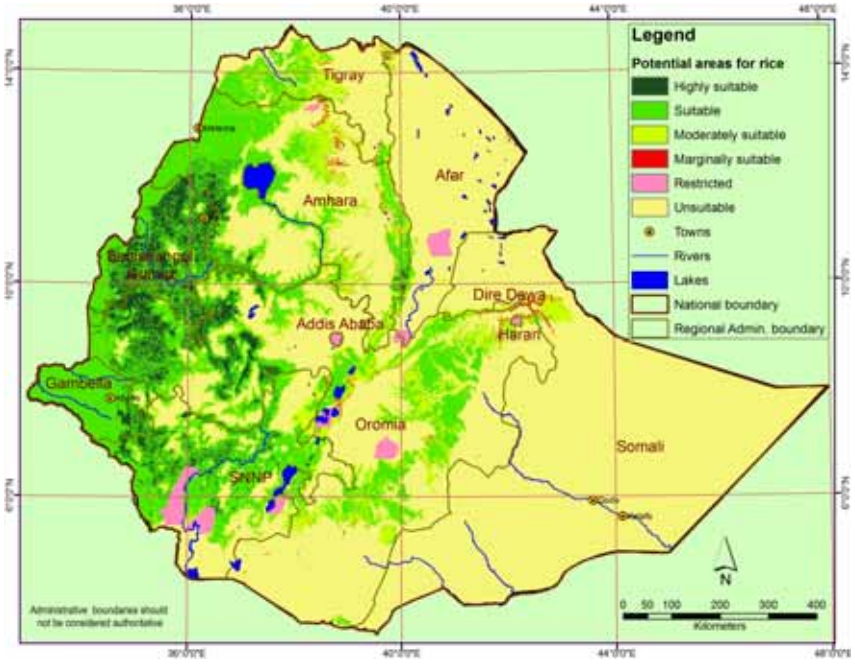

Figure 2 Suitability map of rain-fed rice production in Ethiopia

The country is also endowed with huge irrigation potential. According to Awulachew et al. (2007), the country has about 3.7 million ha of land. The distribution of irrigable land by basin is presented in Table 10.

Table 10. Irrigation potential in Ethiopia by basin

River Basin	Irrigable land (ha)	Region (s)
Tekeze	83,368	Tigray and Amhara
Abay	815,581	Amhara, Oromiya, Benishangul Gumuz
Baro-Akobo	1,019,523	Benishangul -Gumuz, Gambella, Oromiya, and SNNPR
Omo-Gibe	67,928	SNNPR and Oromiya
Rift Valley (Lakes)	139,300	Oromiya and SNNPR
Mereb	67,560	Tigray
Afar /Danakil	158,776	Afar, Tigray, and Amhara
Awash	134,121	Amhara, Oromiya, Afar, and Somali
Wabi-Shebelle	237,905	Oromiya, Harari and Somali
Genale-Dawa	1,074,720	Oromiya, SNNPR, and Somali regions
Total	3,798,782	

Source: Awulachew et al., 2007

3.2.2. Potential of rice in rural poverty reduction and economic growth

Rice has become an increasingly important cash crop in rice producing areas mainly due to its high demand and with relatively stable price trends in the food

market. The followings are some of the existing potentials of the rice production in the country:

- agro-ecologically, the crop can grow in both rain fed and irrigated agro-eco-systems of both lowland and intermediate areas creating the opportunity in poverty reduction in all these target ecologies;
- the number of producers, processors, and traders of rice is increasing from time to time, creating addition livelihood options for many actors. It also serves as a major livelihood option in areas like Fogera plain, which used to suffer from water lodging. This will obviously have direct implication in reducing rural poverty;
- it is relatively less affected by storage pests as compared to other cereal grains such as maize, sorghum, and wheat, which are commonly used in food security measures;
- with recognition of comparative advantages of rice over other food crops, Ethiopia has selected rice as among priority crops and labeled it as a "Millennium Crop" important for food security and income generation;
- the existence of successes recorded in selected areas like Fogera, Chewaka and Gura Ferda areas in the development and dissemination of rice technologies in the country; and
- the huge need to address the shortage of foreign currency either through export expansion or import substitution.

3.2.3. Availability of high yielding and adaptable varieties

The existence of better-established decentralized research system and the considerable number of well-adapted rice varieties can be considered as a potential to promote rice production. At present, there are 12 varieties are for rain-fed and 3 for irrigated agriculture (Table 11). In addition, there are local varieties like X-jigna and Demewoze that perform well.

Table 11. List of released rice varieties as of 2009 in Ethiopia

Name	Ecosystem	Yield (t/ha)	
		Research level	Farmers' level
Pawe-1 (M-55)	Upland	2.0	-
Gumara (IAC-164)	Rainfed lowland	3.4	3.0
Tigabe (IREM-194)	Upland	3.7	3.2
Kokit (IRAT-209)	Upland	3.6	2.8
AD01 (Getachew)	Upland	1.8	1.6-2.5
AD012(Andassa)	Upland	2.5-3.8	2.0-3.1
AD048(Tana)	Upland	2.4-4.1	2.1-3.2
NERICA-1	Upland-irrigated	4.7	3.0
NERICA-2	Upland-irrigated	5.0	3.5
NERICA-3	Upland	4.5	2.9
NERICA-4	Upland	4.8	3.0
Suparica-1	Upland	5.1	2.3
Shebele(IR688059-76-3-3-3-2)	Irrigated	5.9	4.5
Gode-1 (BG-90-2)	Irrigated	5.7	4.3
Hoden (MTU-1001)	Irrigated	4.7	4.0

3.2.4. Availability of technology dissemination channels

Along with the overall improvement in the approaches of agricultural technology dissemination, there is a well-developed dissemination channel also for rice in the country. Channels commonly used for rice technology dissemination in Ethiopia include:

- existence of considerable number of extension workers at both federal and regional level;
- exchange visits of rice scientists, extension officers, processors and farmers from institutions/areas within the country and other countries in ECA;
- the possibility of promoting rice technologies through FTCs (Farmers' Training Centers);
- use of farmers' Research and Extension Group (FREG) in rice technology dissemination, which is now promoted by the NARS and also by MoARD;
- the use of publications (Annual reports, Journal articles and proceedings of scientific meetings/workshops), Newsletters, Extension materials (leaflets, brochure, and posters), Radio and TV programs, Exhibitions/Agriculture shows/Seed fairs and Websites; and
- possibility of rice technology promotion along with commercial and irrigated rice farming.

3.2.5. Existence of conducive policy environment

- government's attention given to rice as a "Millennium Crop";
- establishment of the National Rice Research and Development Steering Committee in 2007 with a possibility of different National Rice Research and Development Technical Committees;
- zero tariff on importation of agricultural machinery and equipment and also agricultural investment incentives;
- large domestic market for rice products and by- products;
- huge public interest in improving the efficiency of agricultural inputs delivery mechanism;
- existence of research and training institutions associated with rice;
- the possibility of linking rice trade with ECX for improved marketing system;
- availability of rice development projects particularly those implemented jointly with Japan through JICA and JIRCAS, SG-2000 etc;
- the Government engagement in the East African Agricultural Productivity Program (EAAPP) of the World Bank, which has a rice R&D component; and
- huge public investment in irrigation schemes from small-scale to large scale projects all over the country

3.2.6. Trans boundary/regional issues

The COMESA initiative plans to establish a free movement of goods and services across countries in the Eastern and Central African sub region. As a result, there is potential to improve trans-boundary rice trade, exchange of market information, research findings, and seed varieties. Currently, there is a smooth exchange of rice germplasm within the region, West Africa through

West Africa Rice Development Association-WARDA (currently, it is renamed as the Africa Rice Center-AfricaRice), and also internationally through IRRI (International Rice Research Institute). The East African Agricultural Productivity Program (EAAPP) of the World Bank, which is going to establish a Regional Center of Excellence for Rice Research in Tanzania to serve all East African countries, is a good opportunity in the coming years in formal germplasm, technology and knowledge exchange in the region.

4. Vision and Scope

4.1. Vision

The vision of the NRRDSE is to see the existing limited area and subsistence-dominated rice sub-sector transformed progressively into commercially profitable and viable production system.

4.2. Goal

To contribute to the development of a viable agricultural sector through establishment of a competitive and sustainable rice production and marketing system

4.3. Objectives

- to increase domestic production from the current about 500 thousand tones to about 4 million tons over a 10-year period through the promotion of gender sensitive and productivity-enhancing innovations of small and commercial local rice producers and entrepreneurs along the rice value chain;
- to promote marketable surplus of local rice through investment in irrigation, quality improvement, value addition and both domestic and regional marketing; and
- to promote stakeholder innovation capacity for the utilization of rice by-products while ensuring sound environmental management practices.

5. Priorities and Approaches

5.1. Approaches

5.1.1. Agro-ecology-based promotion of rice R&D

Ethiopia is known for its agro-ecological diversity with huge potential also for irrigation. In Ethiopia, rice is produced under rain-fed and irrigation condition. In the 2008/09 production season, 155,886 ha of land were allocated for rice, of which 129,106 ha was under rain-fed and 26,780 ha under irrigation. It is projected that the total 773,504 ha of land will be cultivated with rice in 10 years time i.e. by 2019, of which 385,876 ha are projected for rain-fed and the remaining 77,728 ha for irrigated rice. The rice production under rain fed condition is produced in two agro-ecologies namely *Kolla* and Woy*ina Dega* areas, which have distinct agronomic and variety requirements. Therefore, the NRRDSE will give agro-ecology specific attention in the R&D of rice.

5.1.2. Promoting small- and large-scale rice production

Taking into consideration the specific socio-economic conditions of the different potential production areas, the strategy will give emphasis for both small-scale and commercial production of rice. This is important as the needs and requirements of small-scale and commercial production are different with different type and intensity of interventions.

5.1.3. Gender consideration

Cognizant of the labor intensity of rice production and engagement of women and children, and the government's target of addressing gender issues through interventions like introduction of labor saving technologies for rice production and processing, the strategy will consider the gender aspects starting from technology generation up to markets.

5.1.4. Value chain approach promotion

Integrated approach in the R&D efforts following value-chain approach will be promoted for the NRRDSE to make sure that all actors along the chain will get the benefits from rice promotion. This will be ensured through innovations starting from technology adaptation and generation, institutional arrangement, production, post-harvest handling up to marketing of produce domestically and internationally. The engagement of private sector and farmers' organizations (cooperatives, unions and associations) will be promoted along the value chain.

5.1.5. Environmentally sustainability

The strategy will give due emphasis to the sustainability of rice R&D though interventions that will make sure the social, natural resource and economic

sustainability. Implementation of NRRDSE is among interventions, which could have negative environmental impacts if not well planned. Some of the negative impacts could include

- deprivation of water for downstream users due to over abstraction of water and inefficient use by irrigation schemes;
- prevalence of water borne diseases such as malaria, bilharzias, diarrhea due to stagnant water in irrigation systems;
- increased salinity and alkalinity in the soils as a result of poor drainage systems and extensive inappropriate application of fertilizers and agro-chemicals; and
- inundating settlements areas as a result of reservoir extension due to dam construction for the purpose of irrigation development and other uses and land degradation due to clearing of vegetation when introducing new areas for rice cultivation.

To address environmental issues in the course of NRRDSE implementation, the following would be considered:

- creating continuous awareness and monitoring of fertilizer and agro-chemical use to reduce environmental problems associated with it;
- training of farmers on environmental issues related to irrigated agriculture;
- training of technical staff on environmental issues so that they know the implication of irrigation development on environment;
- use of integrated water resource management (IWRM) approach in irrigation development to ensure equity distribution of water resources among different users;
- cumulative environmental impact assessment would be undertaken after every five years; and
- integrated pest management capacity building would be undertaken.

5.2. Priority areas/interventions

Taking into consideration the value-chain and agro-ecology based approaches in the implementation of this strategy, the priority areas are summarized in Table 12.

Table 12 Priority areas and issues to be addressed

Priority areas	Major issues to be addressed
Input availability	Improving access and use of improved varieties and seed for both rain-fed and irrigated, pre-harvest equipments, pesticides, finance and chemical fertilizer
Agronomy	Proper pest management, proper land preparation technique (mainly in Vertisols), method and date of planting, proper seed rate along with type, rate and date of fertilizer application
Irrigation and water management	Proper rehabilitation of existing irrigation and expansion and construction of new irrigation schemes, drainage along with strengthened extension service, human resource capacity development, and proper irrigation agronomy
Post harvest handling	Enhance availability threshing, par-boiling, and milling equipment, safe storage facilities, harvest pilling and transporting, and addressing storage pest problem, timely provision of maintenance services,
Marketing	Promotion of required market infrastructure, along with promotion of knowledge and skill on product grading and marketing options
Utilization	Promotion of proper utilization as food, fuel, and feed along with proper awareness creation measures to change the existing consumption habit
Extension	Strengthening the extension services for rice in the areas of variety popularization, agronomy, irrigation, post harvest and marketing, and utilization
Investment	Wider awareness creation for expanded investment on seed multiplication, irrigation, pre and post harvest equipments including irrigation pumps and other machinery and their maintenance, infrastructure development, and associated human capacity building

6. . Beneficiaries

The beneficiaries of this NRRDSE are the small-scale subsistence farmers who are the major Producers of rice; the different stakeholders including large-scale commercial rice producers; seed producing enterprises; millers and food industries; chemical companies; traders and consumers.

7. Targets

7.1. Projected rice area, production, and yield

Table 13 summarizes the current area and production of rice by region along with the projection up to 2019. Overall, the production level is projected to increase from 498,332 tons in 2009 to about 1.8 million in 2014, and about 4.0 million tons in 2019. The area allocated for rice will increase from about 156 thousand ha in 2009 to about 464 thousand and 774 thousand ha in 2014 and 2019, respectively. The projections were made based on the linear trend forecasting of production area using the data for the last 4 years (2006- 2009).

The assumption in the projection of area and production are:

- Irrigation area for rice will increase on average by about 10.2 thousand ha every year in the first five years and about 18 thousand ha /year in the second five years along with productivity increase from 4 to 5.5 t/ha in 2014 and to 7 t/ha in 2019 due to mainly
    - rehabilitation and construction of new irrigation facilities,
    - increased involvement of investors in rice production mainly in Gambella, Benishangul Gumuz, Amhara, Somali and Afar Regions,
    - expected favorable markets,
    - improved availability of pre and post harvest technologies
    - better adoption of recommended agronomic and other best practices, and
    - high yielding open pollinated (OPV) and hybrid rice varieties will be developed for irrigation
- It is also assumed that rain-fed areas for rice will increases every year with difference for upland and lowland rice. For upland rain-fed rice, the area will increase every year on average by 12 thousand ha in the coming ten years. For lowland rain-fed rice, the area will increase every year on average by 39 thousand ha in the first five years and by 32 thousand ha in the second five years. Along with this increase in the area, it is assumed that the productivity level will increase from 2.7 to 3.2t/ha for upland rain-fed and from 3.2 to 4 t/ha for lowland rain-fed in 2014 and to 3.5 t/ha for upland and 5 t/ha for lowland rain-fed in 2019 mainly due to:
    - expected better utilization of Vertisols,
    - improved involvement of commercial rice farms,
    - expected favorable markets,
    - improved availability of pre & post harvest technologies
    - better adoption of recommended agronomic and other best practices, and
    - high-yielding OPV and hybrid rice varieties will be developed for rain-fed conditions.

Table 13 Projected rice area and production (2009 – 2019)

Region	Year	Area (ha)				Paddy grain production (t)			
		Upland rain-fed	Lowland rain-fed	Irrigation	Total	Upland rain-fed	Lowland rain-fed	Irrigation	Total
Amhara	2009	38,430	30,000		68,430	103,761	96,000	-	199,761
	2014	81,769	63,833	13,624	159,226	261,662	255,330	74,932	591,924
	2019	124,662	97,316	27,248	249,226	436,317	486,580	190,736	1,113,633
Oromiya	2009		12,940		12,940		41,408	-	41,408
	2014		30,805		30,805		123,220	-	123,220
	2019		34,743	15,570	50,313		173,715	108,990	282,705
SNNPR	2009	1,475	27,681		29,156	3,983	88,578	-	92,562
	2014	3,680	69,044		72,724	11,775	276,177	-	287,952
	2019	5,526	103,687	7,785	116,998	19,342	518,434	54,495	592,271
Tigray	2009	3,950	1,200		5,150	10,665	3,840	-	14,505
	2014	18,580	5,965		24,545	59,457	23,859	-	83,316
	2019	32,823	11,117		43,940	114,880	55,586	-	170,466
Gambella	2009		3,350	10,000	13,350		10,720	40,000	50,720
	2014		53,530	20,000	73,530		214,120	110,000	324,120
	2019		93,710	40,000	133,710		468,550	280,000	748,550
Benishangul Gumuz	2009		10,080		10,080		32,256	-	32,256
	2014		58,670		58,670		234,680	-	234,680
	2019		102,260	5,000	107,260		511,300	35,000	546,300
Somali	2009			16,780	16,780			67,120	67,120
	2014			43,984	43,984			241,912	241,912
	2019			71,807	71,807			502,649	502,649
Afar	2009			-	-			-	-
	2014			120	120			660	660
	2019			250	250			1,750	1,750
Total	2009	43,855	85,251	26,780	155,886	118,409	272,802	107,120	498,332
	2014	104,030	281,846	77,728	463,604	332,895	1,127,385	427,504	1,887,784
	2019	163,011	442,833	167,660	773,504	570,538	2,214,165	1,173,620	3,958,323

Table 14 Projected productivity levels in paddy gain and seed production of rice

Description	Rice ecology	2009		2014	2019
		Africa	Ethiopia		
Grain (tons/ha)	Upland rain-fed	3.2	2.7	3.2	3.5
	Lowland rain-fed	2.2	3.2	4.0	5.0
	Irrigated	4.1	4.0	5.5	7.0
	Total	3.1	3.2	4.1	5.1
Raw Seed (t/ha)	Upland rain-fed		2.4	2.9	3.2
	Lowland rain-fed		2.9	3.6	4.5
	Irrigated		3.6	5.0	6.3
Seed multiplication factor	Upland rain-fed		25.9	30.7	33.6
	Lowland rain-fed		30.7	38.4	48.0
	Irrigated		38.4	52.8	67.2

7.2. Projected number of researchers, technicians and extension workers

The projections for extension workers were made based on the number of *weredas*, which are projected to have large area of rice thus requiring a full time extension staff. In addition, by 2019, it is assumed that rice production will expand with increased intensity of technology use, thus requiring more specialized staff at regional level. Moreover, with increasing demand for research in rice, the number of technicians and researchers is expected to grow. Accordingly, it is projected to have 186 full and part-time researchers, 101 rice research technicians, 1326 full, part-time rice extension workers, and 25 part-time rice seed technologists by 2019. The projections of human resource requirements for rice research and development activities are generated based on the assumptions that there will be an increase in:

- the number of research components and/or disciplines to be included in the program,
- the number and quality of research activities in each component and/or discipline addressing rice constraints in different ecosystems,
- the number of research centers dealing in rice, and
- efficient delivery of rice technologies entail adequate, facilitated and motivated human resource n Table 15

Table 15 Number of researchers, technicians and extension workers in 2009 and targets

Year	Agricultural researchers with BSc MSc or PhD			Research technicians			Rice seed technologists			Extension workers spend about 5 -10 hours a week on rice promotion		
	Total	Rice specialists (fulltime)	Rice specialists (part time)	Total	Rice specialists (fulltime)	Rice specialists (part time)	Total	Rice specialists (fulltime	Rice specialists (part time)	Total	Rice specialists (fulltime)	Rice specialists (part time)
2009	23	6	17	12	4	8	7		7	160	-	160
2014	69	18	51	36	12	24	15		15	488	-	488
2019	186	48	138	101	36	65	25		25	1,326	-	1,326

7.3. Government commitment on finance and human resource

The federal and regional governments have been committing its financial and human resources for rice research and development. This will continue along with the other agricultural development intervention of MOARD.

7.4. Governance of NRRDSE

NRRDSE will be implemented by the MoARD with close collaboration of the different directorates within the ministry and the Ethiopian Institute of Agricultural Research (EIAR) at the federal level, and by the Regional Bureaus of Agriculture and Rural Development (BoARD) together with the respective regional agricultural/ pastoral/agro-pastoral research institutes (Figure 3). The management of the strategy at national level will be streamlined within the normal operations of Ministry of Agriculture and Rural Development with the Planning and Programming Directorate taking the leading role. Activities to be carried out will include compilation of NRRDSE budget for each financial year; developing NRRDSE implementation plan for the strategic action areas; and monitoring and evaluation of physical and financial performance of the strategic action areas.

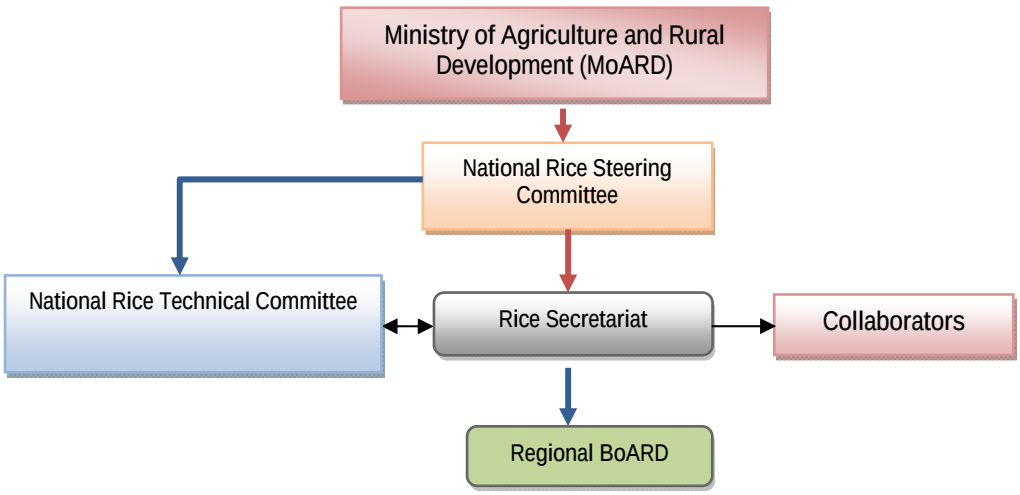

Figure 3 Governance structure of NRRDSE

Members of the National Rice Steering Committee:

1) MoARD
2) EIAR
3) ESE
4) JICA
5) SAA
6) Regional BoARD
7) Regional Agricultural Research Institutes

Collaborators:

1) JICA
2) JIRCAS
3) SAA
4) Others

Members of the National Rice Technical Committee:

1) Crop Research (EIAR)
2) Agricultural Mechanization Research (EIAR)
3) Socioeconomics, Research-Extension and Farmers' Linkage (EIAR)
4) Natural Resources Management (MoARD)
5) Agricultural Marketing (MoARD)
6) Agricultural Extension (MoARD)
7) Ethiopian Seed Enterprise (ESE)
8) Sasakawa Africa Association (SAA)
9) Rice Secretariat (MoARD)

7.5 National stakeholders and linkages to trans-boundary/regional initiatives and partnership building

National stakeholders range from farmers, transporters, traders, processors, agro-dealers, extension staff (crops, mechanization, land use, food technologists, and irrigation engineers), research staff, Community Development Organizations, Development Partners, International Research Institutions, politicians, and policy makers. The overall national stakeholders' linkage at national and regional level and linkage to regional initiatives will be created through the National Steering Committee for Rice R&D, which is chaired by the State Minister of the MoARD. The National Technical Committee will handle the technical aspects of the linkage for Rice R&D and the rice secretariat. A linkage with regional initiative like the EAAPP that have direct importance for the smooth implementation of this NRRDSE will be established and strengthened.

8. Strategies of NRRDSE

In view of the suggested approaches and addressing the priority areas indentified in section 5, the NRRDSE is designed to have nine main strategic components namely

- strengthening the institutional framework and policy development
- research, technology delivery and capacity building;
- production, Multiplication and Dissemination of Certified Seed;
- fertilizer marketing and distribution;
- irrigation and investment in water control technologies;
- pre-harvest mechanization technologies;
- post harvest and marketing;
- supporting maintenance of agricultural equipments, and
- access to credit/ agricultural finance.

8.1. Strengthen the institutional framework and policy development

Cognizant of the decentralization of research and development in the country, strengthening the institutional framework for coordinated endeavor and responsive policy adjustment is very important. Thus, the NRRDSE will give due emphasis in developing further the institutional framework along with the policy process.

8.2. Research, technology delivery and capacity building

As it is for other major cereals, the public research institutes both the federal EIAR and Regional Research Institutes will continue to be the major facilitators and catalysts for breeder and pre-basic seed production along with adaption and generation of new rice varieties for different rice eco-systems and addressing biotic and abiotic stresses. The required amount of breeder and pre-basic seed is summarized in Table 16. The Animal and Plant Health quarantine and Inspection Directorate of the MoARD at national level and Regional Seed Quality Control and Inspection Laboratories at Regional level will oversee the certification of the production of certified seed. However, it should be noted that the capacity of these laboratories is very limited, which requires further strengthening in terms of both human and physical facilities.

For genetic resource development and maintenance, germplasm collection will be continued while molecular tools will be used to characterize and evaluate germplasm for the relevant agro-ecologies. Human and institutional capacity

will be developed and strengthened to meet these requirements. Along with this a National Centre of Excellence for rice research and capacity building will be established, which will contribute to meet these targets.

8.3. Production and dissemination of rice seed

Improved seed is one of the most important components of agricultural modernization process. Efforts for increasing agricultural productivity and production would be a futile attempt without the availability of improved seeds. Until 2009, there was no any formal seed production for the existing improved varieties of rice. In view of this, the strategy would focus on

- production of basic and certified rice seeds;
- strengthening rice seeds distribution network in the country;
- supporting on-farm seed production;
- creating awareness on available seeds of rice varieties to farmers; and
- strengthening the capacity of public and private seed companies to engage in rice seed production.

The overall projection for the different seed classes of improved rice varieties is summarized in Table 16, which was estimated based on the seed multiplication factor and projected productivity levels presented in Table 14. In 2009 cropping season, it is estimated that 12 thousand tons of informal seed was used to plant 156 thousand ha of land. The bases for projection of the requirement of seed are the projected area for paddy grain production of 2014 and 2019. The other assumption considered are productivity of seed, which is assumed to be less by 10% than the projected grain productivity, clean seed recovery (80%) and average seed rate per ha (0.075 t/ha) as noted in Table 14. It should also be noted that, for example, for the certified seed required in 2014 paddy grain production, the breeder, pre-basic, basic and certified class seed should be produced in 2010, 2011, 2012, and 2013, respectively. Based on these assumptions, it is projected that 35 thousand and about 58 thousand tons of certified class seed in 2014 and 2019 need to be produced, respectively.

Table 16. Projected demand of the different class of clean rice seed (t)

Region	Year	Certified				Basic				Pre Basic				Breeder			
		Upland rainfed	Lowland rainfed	Irrigation	Total	Upland rainfed	Lowland rainfed	Irrigation	Total	Upland rainfed	Lowland rainfed	Irrigation	Total	Upland rainfed	Lowland rainfed	Irrigation	Total
Amhara	2009	2,882.25	2,250.00	-	5,132.25												
	2014	6,132.71	4,787.44	1,021.80	11,941.95	199.63	124.67	19.35	343.66	6.50	3.25	0.37	10.11	0.21	0.08	0.01	0.30
	2019	9,349.64	7,298.71	2,043.60	18,691.95	278.26	152.06	30.41	460.73	8.28	3.17	0.45	11.90	0.25	0.07	0.01	0.32
Oromiya	2009	-	970.50	-	970.50												
	2014	-	2,310.37	-	2,310.37	-	60.17	-	60.17	-	1.57	-	1.57	-	0.04	-	0.04
	2019	-	2,605.72	1,167.75	3,773.47	-	54.29	17.38	71.66	-	1.13	0.26	1.39	-	0.02	0.004	0.03
SNNPR	2009	110.65	2,076.05	-	2,186.70												
	2014	275.99	5,178.31	-	5,454.30	8.98	134.85	-	143.84	0.29	3.51	-	3.80	0.01	0.09	-	0.10
	2019	414.46	7,776.51	583.88	8,774.85	12.34	162.01	8.69	183.03	0.37	3.38	0.13	3.87	0.01	0.07	0.002	0.08
Tigray	2009	296.25	90.00	-	386.25												
	2014	1,393.52	447.35	-	1,840.88	45.36	11.65	-	57.01	1.48	0.30	-	1.78	0.05	0.01	-	0.06
	2019	2,461.71	833.79	-	3,295.50	73.27	17.37	-	90.64	2.18	0.36	-	2.54	0.06	0.01	-	0.07
Gambella	2009	-	251.25	750.00	1,001.25												
	2014	-	4,014.75	1,500.00	5,514.75	-	104.55	28.41	132.96	-	2.72	0.54	3.26	-	0.07	0.01	0.08
	2019	-	7,028.25	3,000.00	10,028.25	-	146.42	44.64	191.06	-	3.05	0.66	3.71	-	0.06	0.01	0.07
Benshangul	2009	-	756.00	-	756.00												
Gumuz	2014	-	4,400.25	-	4,400.25	-	114.59	-	114.59	-	2.98	-	2.98	-	0.08	-	0.08
	2019	-	7,669.50	375.00	8,044.50	-	159.78	5.58	165.36	-	3.33	0.08	3.41	-	0.07	0.001	0.07
Somali	2009	-	-	1,258.50	1,258.50												
	2014	-	-	3,298.80	3,298.80	-	-	62.48	62.48	-	-	1.18	1.18	-	-	0.02	0.02
	2019	-	-	5,385.53	5,385.53	-	-	80.14	80.14	-	-	1.19	1.19	-	-	0.02	0.02
Afar	2009	-	-	-	-												
	2014	-	-	9.00	9.00	-	-	0.17	0.17	-	-	0.003	0.003	-	-	0.0001	0.0001
	2019	-	-	18.75	18.75	-	-	0.28	0.28	-	-	0.004	0.04	-	-	0.0001	0.0001
Total	2009	3,289.15	6,393.80	2,008.50	11,691.45												
	2014	7,802.22	21,138.47	5,829.60	34,770.29	253.98	550.48	110.41	914.87	8.27	14.34	2.09	24.69	0.27	0.37	0.04	0.68
	2019	12,225.81	33,212.48	12,574.50	58,012.79	363.86	691.93	187.12	1,242.91	10.83	14.42	2.78	28.03	0.32	0.30	0.04	0.66

**. The seed used in 2009 is informal seed.*

8.4. Fertilizer marketing and distribution and sustainable soil management

Fertilizer distribution in Ethiopia is highly supported by the Government with the support of donor communities. The distribution is handled through bulk purchase by AISE and formal distribution through cooperatives and unions. It is expected that the importation and distribution will continue in similar pace making sure that fertilizer will be supplied to rice producers smoothly. Based on agronomic practices and the projected area under rice production, fertilizer consumption is projected to 26.8 thousand tons in 2014 and 82 thousand tons in 2019. For better competitiveness and sustainable soil fertility management, however, other measures need to be promoted like composting, farmyard manure, and proper crop rotation. In addition, there is a need to strengthen both federal and regional soil test laboratories.

8.5. Irrigation and investment in water control technologies

Irrigated agriculture in Ethiopia is dominated by smallholder farmers largely categorized either traditional or small-scale irrigation. The Government of Ethiopia is currently increasing its support and involvement in improving traditional irrigation systems as well as expands areas under modern irrigation to increase agricultural productivity and improve rural livelihood through producing market oriented economic crops which include rice as one of the priority crops.

To increase rice production under irrigation, existing irrigation schemes will be rehabilitated while new irrigation schemes (gravity) will be developed. In the rain fed lowlands, communities will be encouraged to participate in the development of simple and low cost rainwater control structures (various soil-moisture conservation technologies) for improved rice production. Staff at all levels and farmers will be trained in the operation and maintenance of schemes. Water measuring devices for improved water usage under irrigation will be provided. More efforts will be done on establishment and strengthening of Water Users Association (WUA).

The development of new irrigation schemes will be prioritized by taking into account:

- current rice growing practices and the size of rice potential area;
- the presence of gravity-fed water and the availability of participation by local populations;
- the level of development of the private sector, especially in the field of pre and post harvest technologies for rice production.

Therefore, irrigation and investment in water control technologies would focus on the following areas as classified into implementation period of:

- Short term (1-3 years) strategies:
  - increasing irrigation extension and management systems through staff and beneficiaries capacity building;
  - rehabilitation of existing irrigation schemes (adopting sustainable system and mechanisms on repair and maintenance of irrigation schemes and introducing efficient irrigation systems for rice production);
  - construction of rainwater harvesting and storage structures for small-scale irrigation and improving soil moisture through promotion of in-situ soil moisture conservation technologies;
  - promotion of appropriate irrigation water management/agronomy to prevent salinity problems;
  - strengthening collaboration and linkages between national, regional and international institutions involved in irrigated rice research and development program; and
  - upgrading tradition irrigation schemes to modern small-scale irrigation system.

- Medium- (3-5 years) and long-term (5 years onwards) strategies:
  - expansion of areas in lowland irrigation through constructing new irrigation and drainage schemes and rehabilitating the existing ones;
  - increasing access to improved water saving irrigation technologies; and
  - encouraging investment in medium and large-scale irrigation schemes.

For sustainable irrigated rice production (i) participatory planning and implementation; (ii) monitoring and evaluation of irrigation intervention as part of integrated watershed management (IWSM) approach, and (iii) establishing strong water users association are important to ensure equity distribution of water resources among different users.

8.6. Pre-harvest mechanization technologies

The rice farming practice in Ethiopia is dominantly traditional with overwhelming participation of small-scale producers with small farm size. Similarly, the status of agricultural production mechanization in rice production for the different steps such as soil tillage, planting, harvesting, and threshing is very low. Draft animals and human power are the main sources of farm power. Almost all of the farm operations are performed with bare hand or using rudimentary hand tools and traditional animal drawn implements. Different implements like ploughs, harrows, planters, and weeder were developed and some were introduced from elsewhere and given out to the farming community. However, effective use of these technologies has been minimal and only scattered use of improved ploughs is observed in some parts of the country.

Cultivation of rice on Vertisols had been practiced at Pawe *wereda* with complete mechanization service under the management of Tana Beles project. The project was known to assist the settlers in providing mechanization service.

After termination of the project, the vast areas that were previously used for rice production using heavy machine are out of production. However, few settlers themselves started rice production by their own management on drained Vertisols.

Therefore, dissemination and promotion of existing pre-harvest technologies along with adaptation and generation of other improved technologies need to be strengthened together with human and physical capacity building. The specific interventions are:

- strengthening the popularization and dissemination of proven pre-harvest equipment;
- encourage suitable mechanical power technology in the form of cooperatives and multi farm use;
- develop an industrial extension program for large-scale production, extension and marketing of tools and implements;
- providing opportunities for training and train more researchers and extension engineers in the NARS;
- assisting and strengthen local manufacturers of tools and implement. Form new or strengthen and enhance the capacity of existing micro and small scale enterprises through training and providing opportunity for the establishment of small workshop to manufacturers of improved agricultural tools and implements locally;
- introduce and evaluate implements for tillage and planting to improve present traditional practices;
- strengthening the introduction of pre-harvest equipment (technology shopping); and
- design and testing of improved rice pre harvest equipment

8.7. Post-harvest and marketing

Introduction of more efficient technologies for handling, drying, storing, and milling rice at the village level is essential to reduce post-production losses. The present impressions are that post-production is labor intensive, as the operations involve harvesting hand-reaping, field sun drying before threshing, threshing by trampling, and wind winnowing. This results in poor quality milled rice. Therefore, the strategy would promote

- introduction of affordable and efficient small-scale post harvest tools and equipments;
- group marketing through existing primary cooperatives and their unions in order to boost farmers bargaining power of small-scale farmers; and
- establishment of wider links in the rice trade and linking with Ethiopian Commodity Exchange (ECX) so as to be able to compete in regional and world market.

The specific interventions are:

- strengthening extension services to ensure rice farmers get appropriate advice for post harvest management;
- enhancing the availability and use of efficient postharvest handling and processing equipments taking into account the existing constraints such as lack of equipments for milling, grading, packaging and by-product utilization and ensuring that all rice farmers at the *wereda* level have access to modern processing, packaging and grading technologies;
- strengthening farmer groups, which are present at present and/ or form new farmer groups, at least one sustainable farmer group per village. This will enable farmers to access financial services, for example, loans and farm machinery services more easily and at affordable prices;
- strengthening partnerships between different stakeholders involved in agricultural activities especially those involved in post harvest activities;
- professional training for researchers/extension officers at masters and/or PhD degree level for selected few will be needed on technology development for primary processing with agricultural engineering background;
- promote improved rice by-product (hull and bran) utilization techniques
- Strengthening the introduction of post-harvest equipment (technology shopping);
- design and testing of improved rice post-harvest equipment;
- promotion of group marketing through existing primary cooperatives and their unions in order to boost farmers bargaining power of small-scale farmers; and
- establishing wider links in the rice trade and linking with Ethiopian Commodity Exchange (ECX) so as to be able to compete in regional and world market.

8.8. Supporting maintenance of agricultural equipment

Agricultural equipment like irrigation plumbs, irrigation control systems, pre and post-harvest equipments require technical backstopping for timely maintaining and skill development. Reliable and timely provision of maintenance services, spare parts, fuel, and lubricants for the stated equipments mainly in rural areas is very important in promoting rice production and productivity. Therefore, the NRRDSE will promote both large scale and micro enterprises for effective management of agricultural equipment maintenance. This includes capacity development of farmers in technical issues, business mgmt, and entrepreneurship.

8.9. Finance and credit

In promoting most of the interventions suggested in this strategy, it is important that they are associated with access to finance. Mechanisms will be designed to link primary cooperatives, unions, credit, and saving institutions, microfinance institutions, and formal private and public financial institutions in improving access to finance to rice sector actors.

9. Implementation Strategy

9.1. Institutional and implementation arrangements

The NRRDSE will be implemented in phases of short- (1-3 years), medium- (3-5 years), and long-term (> 5 years) taking into consideration the country's decentralized research and development in the agricultural sector.

Short-term strategies would be focusing on:

- variety development and appropriate agronomic practice;
- increasing production and productivity of rice in both rain-fed and irrigation schemes;
- reducing pre and post-harvest production losses;
- increasing availability of agricultural inputs (improved seeds, fertilizers, pesticides and appropriate farm machineries);
- rehabilitation existing irrigation schemes; and
- Improvement in post harvest management and marketing.

Medium and long-term strategies would continue complementing the interventions that was implemented during the short-term period and thus be focusing on:

- further development of improved varieties including hybrid once;
- expansion of areas in irrigated together with construction of new irrigation schemes, rain-fed lowland and up-land ecosystems;
- increasing access to farm machinery and pre and post harvest technologies; and
- encouraging investment in medium and large-scale processing industries.

Both the short-term and long-term strategies will be linked with capacity building both in human and physical facilities in the Research and development aspect of the rice sector.

For effective implementation of the strategy, along with the Rice Secretariat at MoARD, Adet Research Center of the Amhara Regional Agricultural Research Institute will serve as the Center of Excellence for Rice Research and Training. However, there is a need to strengthen the research center in terms of human and physical facilities. Specifically, there is a need to establish a well-flagged site(s) for rice germplasm maintenance and seed multiplication, and establishment of required facilities for training.

In addition to the formal interventions that will be designed through the yearly planning processes of the MoARD and other partners, specific projects on the

different aspects of the rice R&D will be designed and implemented in the short, medium, and long-term period.

9.2. Partnership arrangements

The NRRDSE will be promoting effective partnership with all stakeholders within the country and abroad like IRRI, AfricaRice, JIRCAS, and CARD. The National Rice R&D Steering Committee will take the responsibility in strengthening this partnership. In addition, the Agricultural and Rural Development Partners' Linkage Advisory Council at federal, regional, zonal and *wereda* level will play in further strengthening the linkage among stakeholders.

Project based collaboration in promoting effective partnership among all stakeholders will serve as an approach in implementing the different aspects of the NRRDSE.

9.3. NRRDSE financing

In addition to the governments funding in most of the interventions, project based partnership in funding selected R&D activities will be promoted. The National Rice R&D Steering Committee together with the Rice R&D secretariat will overlook the development of specific projects. In promoting finance intensive activities like irrigation schemes, it is suggested to (i) promote cost-sharing mechanisms with beneficiaries (small-scale farmers, private investment) in installation and maintenance, (ii) donor assisted irrigation schemes; and (iii) public funded irrigation schemes.

9.4. Sustainability

The due attention given by the GoE for the development of the sector and existing potentials along with recent tremendous expansion in rice production, confirms the huge potential of sustainability of promoting the sector. In addition, the established partnership between rice producing countries and the Secretariat of the Coalition for Africa Rice Development (CARD) and the Network established between national institutions with international institutions associated with rice development (EIAR, KARI, NARO, Africa Rice, and IRRI etc) is expected to ensure regular supply of new technologies. In this regard, strengthening the started public interventions along with the strengthened partnerships and networks is a key in promoting the sustainability and competiveness of the sector.

10. Conclusion

The NRRDSE is prepared taking into consideration the existing potentials and opportunities to enhance rice sub-sector along with the overall national policies and strategies put in place in promoting economic growth in general and agricultural growth in particular. In particular, emphasis would need to be placed on research and technical assistance for expanding and improving paddy production and output of milled rice. This can be achieved through adaptation of existing and new improved technologies as well as up and / out- scaling of such technologies in order to maximize their impact. In promoting technology transfer and adaptation, cooperation between different national and regional institutions engaged in the development of these technologies would be sought. This approach would help to minimize over-lap in research activities and capitalize on the research results.

Another area of priority would be resource management to encourage sustainable rice development. In pursuit of this, efficient and effective use of land resources mainly irrigable land resources and agro-chemical inputs as well as sound agronomic and soil and water conservation practices that ensure long term environmental and crop stability would be supported. Furthermore, due attention would also be given to the promotion of irrigated rice by rehabilitation and construction of new irrigation schemes, improved post harvest handling, processing, and marketing. In line with limited traditional skills in food preparation and consumption habits, measures for encouraging the greater consumption of rice locally especially in rural areas woulde be promoted in order to boost the demand. Along with the stated interventions, human resource development through effective short and long-term trainings for research and development practitioners would be promoted. The extension service will also be given to all actors along the rice value-chain so that developed innovations will reach the targets.

The strategy targets increasing the production of rice from about 500 thousand tons in 2009 to about 1.9 million in 2014 and to about 4 million tons in 2019 along with the increase of area allocated from about 156 thousand ha in 2009 to about 464 thousand and about 774 thousand ha in 2014 and 2019, respectively. The demand for certified rice seed is projected to be about 35 thousand and 58 thousand tons in 2014 and 2019, respectively. In terms of skilled human resource requirement, it is projected to have 186 full and part-time researchers, 101 rice research technicians, 25 part-time rice seed technologists and 1,326 full and part-time rice extension workers by 2019.

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