COMPARATIVE STUDY ON IMPLEMENTATION SYSTEM OF MODERN VARIETIES: NERICA IN CONTEMPORARY SUB-SAHARA AFRICA AND MODERN VARIETY WHEAT DURING GREEN REVOLUTION IN MEXICO, INDIA, AND PAKISTAN

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ABSTRACT

Food security in Sub-Sahara Africa (SSA) is severely threatened. Historically, Latin America and Asia have experienced severe famine, however, Green Revolution (GR) and the development of modern variety grains dramatically improved the starvation, and such a successful story has motivated many researchers to achieve the eradication of hunger in SSA by introducing innovative scientific technologies in agriculture. New Rice for Africa (NERICA) is one representative outcome of the challenge, in the sense that it has high adaptability to the harsh environment in SSA. In 2001, NERICA was introduced in Guinea and Cote d'Ivoire and by 2009, NERICA has been adopted in more than 30 countries (Diagn *et al*, 2011). NERICA also shows higher yields than the traditional varieties, as well as positive economic impacts on farmers. However, when NERICA is compared to GR in the 20th century, the adoption rate is lower; NERICA took 8-10 years to achieve an increase of 5 percent coverage of the total rice-growing land in Africa, whereas the modern variety wheat during GR achieved an increase of 50 percent coverage in Latin America and Asia (Evenson *et al*, 2003). Even though rice consumption in Africa has been increasing and 40 percent of rice is imported, why is NERICA adoption stagnated compared to the modern variety wheat that was developed during GR? My hypothetical answer is that GR achieved a higher adoption rate due to a better implementation system (which refers to the research,

development, and expansion of MVs) which was supported by an efficient and focused international aid through a top-down approach. Contrarily, diverse stakeholders and the failure of a bottom-up approach lowered the efficiency of the implementation and caused a stagnation of NERICA adoption.

This research is conducted based on literature and document reviews. In chapter three and four, I analyze the similarities of the domestic social conditions of each country (India, Mexico, Pakistan, and SSA), and the differences in the condition of the international society during the time which the two different modern varieties were implemented (1940s-60s for GR and 1990s-present for NERICA) to identify if the implementation system is a key factor that affected adoption rate of each modern variety wheat and NERICA.

In chapter five, I describe comparative analysis that I conducted on the implementation system of both modern variety wheat and NERICA based on *Organization Theory* (Burns & Stalker, 1961). The theory's approach is descriptive and it indicates two different forms of organization: one is called *mechanistic* which is a form of bureaucratic organization, and the other is *organic*, a non-bureaucratic organization. The representative features are: a vertical relationship and a rules and regulations bounded behavior of the members are found in a mechanistic organization, and a horizontal relationship and maximized personal discretion of the members are found in an organic organization. Based on the results of the comparative analysis, the descriptions about important stakeholders are determined to illustrate each

implementation system: the organizations in the NERICA implementation could be described as mechanistic forms, although NERICA aims to realize organic forms to overcome the umpteenth historical failures in development aids. In fact, NERICA implementation has respected self-help effort of SSA countries and avoided hierarchical framework and relationship; the projects and programs have been formed under titles of ‘collaboration,’ ‘partnership,’ and ‘network’ among SSA countries, donor countries, and international agencies. However, In terms of behaviors of the stakeholders and organizational milieux, NERICA implementation demonstrates the mechanistic features, whereas semi-dwarf wheat during GR demonstrates the organic features though its systems and the relationships between donors and recipients were hierarchical and bureaucratic.

The last chapter concludes the research by showing unrestricted behaviors (i.e. maximized personal discretions and minimized rule bounded behaviors) of the stakeholders increase the efficiency of MVs’ implementation system. Therefore, what donors for research and development of modern varieties should do to improve the adoption rate of modern variety agricultural product is to increase unrestricted grant and to maximize member’s ability to use his on projects and program.

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DEDICATION

I dedicate my master thesis to my family who allow me to extend my academic career, for their generous and patient supports, because without their help I would have never been able to complete my thesis or master course.

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LIST OF ABBREVIATIONS

ADB	African Development Bank
ARI	Africa Rice Initiative
AfricaRice	Africa Rice Center/ WARDA
CARD	Coalition for African Rice Development
CGIAR	the Consultative Group on International Agricultural Research
CIMMYT	International Center for Maize and Wheat Improvement
FAO	Food and Agriculture Organization
FF	Ford Foundation
GNI	Gross National Income
GR	Green Revolution
ILO	International Labour Organization
IMF	International Monetary Fund
IR	International Relations
JICA	Japan Institutional Cooperation Agency
LDCs	Less developed countries
MAP	Mexican Agricultural Project
MOFA Japan	Ministry of Foreign Affair of Japan
MDGs	Millennium Development Goals
MV(s)	Modern variety(s)
NERICA	New Rice for Africa
OSS	Office of Special Studies (in Chapingo, Mexico)/ former CIMMYT
PVS	participatory varietal selection
RF	Rockefeller Foundation
SAA	Sasakawa Africa Association
SSA	Sub-Sahara Africa
U5MR	Under five mortality rate
UK	United Kingdom
UN	the United Nations
The US	the United States of America
USDA	United States Department of Agriculture
WARDA	West Africa Rice Development Association/former AfricaRice
WB	the World Bank
WHO	World Health Organization
WWII	World War II

LIST OF UNITS OF MEASUREMENT

ha	hectare(s)
tonne(s)	ton(s), 1000kg
USD	United States dollars

1 INTRODUCTION

1.1 Controversial Aspects of Modern Varieties

Why was NERICA's adoption stagnated in Sub-Sahara Africa (SSA)? NERICA stands for New Rice for Africa and it is a hybrid and high yielding rice developed by Dr. Monty Jones in 1994. Increasing agricultural productivity in less developed countries (LDCs) always promises contributing to increase food security, to alleviate poverty, and to develop their national economies, thus, research and development on modern varieties (MVs) of agricultural products have been taking place for a century all over the world. NERICA is one representative outcome of the challenge in the sense that it has high potential of adaption to the harsh environment in SSA. However, its adoption rate remains low: after NERICA was spread in Côte d'Ivoire for the first time in 1996, more than 30 countries adopted NERICA by 2009. Furthermore, NERICA was planted 700,000 ha in Africa and it was only 5 percent of the continent's upland rice growing area (Diagne *et al*, 2011). Although 700,000 ha and 5 percent coverage within approximately 10 years seem to be achieved a large adoption, they are still small and slow compared to the adoption rate of MVs during the Green Revolution (GR) in the 1940s to 1960s. Generally, GR refers to "the development of high yielding varieties for major food crops important to developing countries. […] The Green revolution is

a continuing process of change rather than a single event. (Hazell, 2009)" Going back to the history of MVs, the first modern variety that was developed in the world was modern variety wheat (semi-dwarf wheat) by Dr. Norman Borlaug in Mexico and the adoption rate of the wheat was much larger than NERICA: 60-80 percent in Mexico, India, and Pakistan within about 10 years (CIMMYT, 1989). In this research, GR refers to the semi-dwarf wheat in Mexico, India and Pakistan and excludes all other MVs in Latin America and Asia to focus on the early stage of MVs adoption for both varieties.

What is MVs? MVs is the improved agricultural products through hybridization—cross-breeding (Dalrymple, 1980) (will be discussed in detail in 1.3 Summaries and Limitations of Past Modern Varieties Studies: Natural Scientific Perspectives). Besides that, MVs is the controversial issue. Here, I would like to present both advantages and disadvantages of MVs. Generally, the criticisms about GR is con-MVs and goals of NERICA is made based on pro-MVs arguments.

Development of MVs is often criticized by environmentalists initiated by Rachel Carson's *Silent Spring* (1962). In her book, she warned of the dangers of pesticides (DDT) to developed countries that enjoy economic development at the expense of nature and surrounding environment. Thus, soon after MVs were spread all over the world, they were targeted by environmentalists. This is partly because when MVs were implemented in LDCs, they also required improvement of agricultural practices, for instance, usage of chemical

fertilizers and construction of scientifically effective irrigation systems. Moreover, consequent negative social events occurred one after another such as soil deterioration and economic gaps between the poor and the rich. As a result, those events tend to be attributed to only MVs and many demonize MVs as the source of all evil.

For example, in 1960-80, several regional and intranational conflicts occurred in Punjab in the northern part of India, and those conflicts attributed to the semi-dwarf wheat where the first modern variety wheat was implemented in India. Since the middle of the 1960s, Punjab adopted semi-dwarf wheat and its high growth of the products served as the driving force of adoption of MVs in India and Pakistan. Besides the increasing production of wheat, Vandra Shiva, author of *The Violence of the Green Revolution* (1991) notes that GR accelerated water conflicts (at least 15,000 casualties in 1980-1986), and undermined cultural values and traditional agriculture in Punjab. He argues that the semi-dwarf wheat requires more water than traditional varieties. Consequently, in Punjab where it was already suffering from water shortage, the confrontations over the irrigation water occurred among different ethnic groups and states. At first, the conflicts were waged in the political arena, however, later, it spilled over military arena. In addition, Shiva claims Indian traditional cultivations have been lost after MVs' implementation such as the practice of using organic fertilizers, thus, the soils were degraded, the production of foods even decreased, and the small-scale farmers starved.

For those con-MVs arguments, Norman Borlaug (founder of the first MVs and pro-MVs position) refutes that those negative social events could be avoidable if the management of MVs works properly. First, MVs' fertilizer response is high enough to avoid fertilizer over use, and one spoon of fertilizer works enough in Africa has been already proved. Hence, the criticism that MVs cause over fertilizer use is not correct. Second, Borlaug protested that comparative studies and researches since 1835 clearly proved that chemical fertilizers do not deteriorate soil. Soil degradation in India and Pakistan was caused by sewage contamination, and salination, and those are caused by low quality of irrigation systems. Third, about the fact that water scarcity is often claimed after the implementation of MVs and new irrigation systems, however, again, it is not true about MVs. It is true that MVs require development of irrigation systems to fully extract their potential, but it does not have to be groundwater. In several dry areas, MVs achieved higher productivity than that of traditional varieties only with rain-fed land. Last, as for the criticisms that MVs widened the gap between the poor and rich, Borlaug protests that what he aimed for in the development of MVs was saving small-scale farmers whereas MVs equally benefit for both large and small farmers. In the end, large farmers benefited more due to their larger lands, however, this necessarily mean only the large farmers could benefit from MVs (Yamamoto, 1997[1]).

To recapitulate, applying Borlaug's arguments to the case of Punjab, attribution of semi-dwarf wheat to conflicts is an oversimplification—omitting relevant considerations to

[1] All paraphrasing from original Japanese references was done by the author.

imply that there is a single cause or solution for a complex problem. In the first place, Punjab was not a stable or secure area, and historical grievances were found among different ethnic groups at least since the independence of Pakistan in 1947. Moreover, although MVs could be one of the reasons that triggered water conflicts, the major cause of the conflicts could be identified as unstable politics that failed to manage water allocation to those antagonistic ethnic groups. Lastly, as long as traditional practices were not effective enough to solve hunger (in fact, before semi-dwarf wheat was adopted, people suffered from severe hunger in India), those practices would have been replaced with modern agricultural methods sooner or later under the name of globalization even if MVs had not been implemented. Therefore, such oversimplification rather possibly hinders development of political management system and consensus building in society.

On the other hand, Pro-development of MVs interprets that the development of MVs is directly linked to increasing food security in LDCs. Generally, the base of pyramid (BOP) in development countries is small-scale farmers. In fact, in SSA, three quarters of BOP live in rural areas and often they are small farmers (Niki, 2008), and "improving small farm productivity will be the most effective way to achieve mass poverty reduction in rural areas in SSA (Irz *et al*, 2001; Kydd *et al*, 2004; Lipton, 2005; Hazell, 2005) (Orr *et al*, 2008)." Therefore, theoretically, high yielding varieties (another name for MVs) could contribute to

increasing productivity of those poor, small-scale farmers and consequently, they increase the food security in LDCs. Niki explains:

> In the distant and isolated rural area, all farmers are small scaled and no other industries to support their living. In order to eradicate famine in SSA, promoting subsistence agriculture by increasing productivity of small farmers in rural area will be the one realistic solution (Niki, 2008).

Thus, in terms of hunger eradication in LDCs, the importance of focusing on small scale farmers has been acknowledged by the researchers, and possibility of increasing productivities of small scale farmers has been pursued.

These discussions were strengthened after the tragedies in SSA. Population pressure and the lack of land and food caused a serious crisis. One of the biggest tragedies was the Rwandan genocide in 1994. An environmental scientist, Jared Diamond interoperates the cause of genocide in Rwanda was "population pressure […] which makes people chronically desperate and [is] like the gunpowder inside the powder keg (Diamond, 2005)." Traditionally, in Rwanda, people leave their land to their children by dividing it by the number of the children. Due to the growth in population, children could not inherit enough agricultural land to produce their own food in the beginning of 1990, before the genocide took place. Moreover, many Hutu refugees, over 200,000 Burundian Hutu fled to Rwanda. As a result, the land resources that were available for each citizen got dwindled. Worst of all, severe draught hit

Rwanda twice in a year of 1993, and triggered starving citizens to murder one million Tutsi.

Diamond added:

> It is not rare, even today, to hear Rwandans argue that a war is necessary to wipe out an excess of population and to bring numbers into line with the available land resources [and] all these people who were…killed had land and cows. And somebody had to get these lands and those cows after the owners were dead. In a poor and increasingly overpopulated country this was not a negligible incentive (Diamond, 2005).

Even Rwandan people acknowledged that the conflict was caused by population pressure and the depletion of agricultural land, which means lack of ability to produce their own food. Because many African countries are politically unstable due to ethnicity, religion, natural resources and other reasons, they are more vulnerable to food shortages and future Rwandan genocides possibly happen again that could be avoidable if only there were food for everyone.

Those reasons represented a philosophy about continuous MV developments by many scientists and large research and development investment budget by international society although GR and its negative social consequences were severely criticized. However, in fact, the budget of research and development of MVs is more restricted than before and put under more control of the donor countries and organizations (World Bank, 2004), and many environmentalists and social scientists protest the MVs and GR were causes of serious environmental degradation and social conflicts.

1.2 Summaries and Limitations of Past NERICA Studies: Social Science Perspectives

NERICA is not a well-researched topic yet and "unfortunately, there are relatively few published reportes available with which to evaluate [the claims on NERICA] (Orr *et al*, 2008)." As Aliou Diagn *et al* mentioned in their book, one crucial factor that constrains the further adoption of NERICA is that the research capability of SSA is desperately low, for instance, there are about 250-275 researchers in total from AfricaRice member states (Diagn *et al*, 2011). Among the literature about NERICA, more research and study in the natural science fields are found compared to the research in the social science fields. According to the academic research service, 'web of knowledge,' 103 articles are hit for the topic under 'NERICA,' and when it was narrowed down into social sciences category, only nine articles were hit[2]. That result clarified that social science research on NERICA is limited and indicated a necessity for further research. Hence, this research that aims going beyond the existing studies based on the comparison of NERICA with GR from the perspectives of implementation system (which referred to the research, development, and expansion of MVs) of MVs should be justifiable.

[2] Result of 'web of Knowledge':
Topic=(NERICA); Refined by: Research Domains=(SOCIAL SCIENCES), Time span=All years, Search language=Auto; and **Results: 9**. Retrieved October 28, 2013 from http://apps.webofknowledge.com/summary.do?locale=en_US&SID=Y2vj7zisy6sA5ckLxJk&product=UA&qid=4&search_mode=Refine

Before summarizing the literature review, I would like to introduce the status quo of NERICA's adoption. As shown in figure 1, NERICA has been implemented in more than 30 countries: Benin, Burkina Faso, Burundi, Cameroon, Central African Republic, Chad, Republic of the Congo, Côte d'Ivoire, Democratic Republic of the Congo, Eritrea, Ethiopia, Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Liberia, Madagascar, Malawi, Mali, Mauritania, Mozambique, Niger, Nigeria, Rwanda, Senegal, Sierra Leone, Sudan, Togo, Uganda, United Republic of Tanzania, and Zimbabwe (Gridley *et al*, 2002 and Diagn *et al*, 2011).

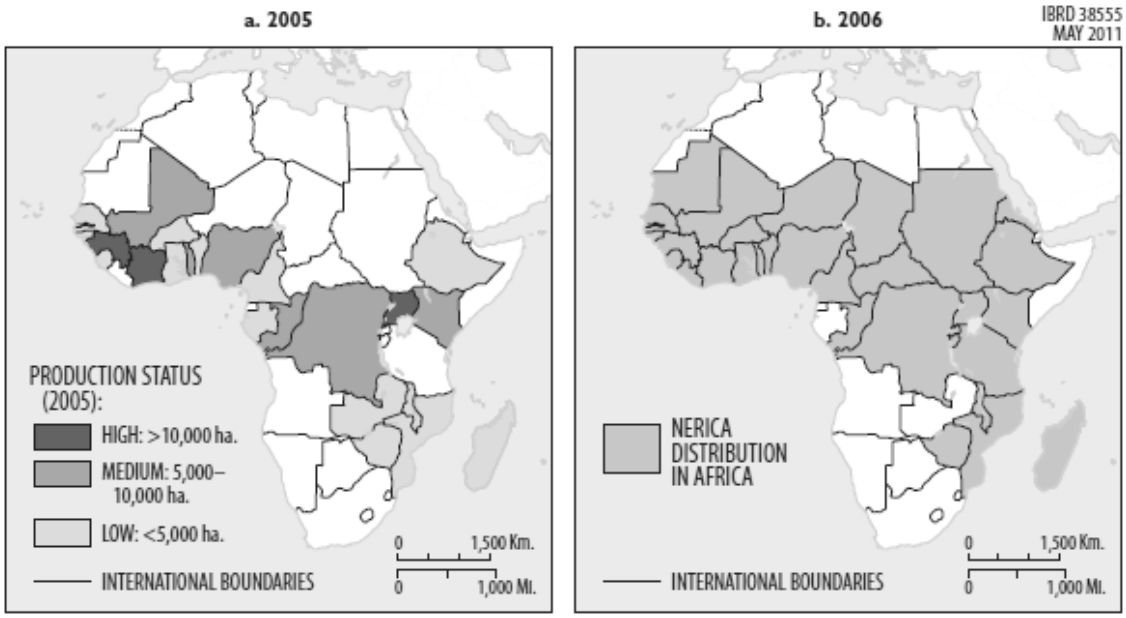


Figure 1 Areas of Sub-Saharan Africa producing NERICA varieties, 2005, 2006
(Source: Diagn, *et al*., 2011)

The available data of NERICA's adoption by each country is shown below. NERICA achieved 5 percent of the African continent's upland rice growing area by 2009 in total (Table

1). Interestingly, Uganda which is not traditional rice eating country achieved the highest coverage rate, approximately 30 percent.

Table 1 Estimated area under NERICA (ha) and its ratio

		2002	2003	2004	2006	2007	2009
Africa	**NERICA**				200,000		700,000
	(%)				1.4		5
Benin	**NERICA**		5,000				
	RICE	29,759	23,412	24,754	26,901	27,324	40,856
	(%)		21.4				
Guinea	**NERICA**	28,000		51,000			142,391
	RICE	629,703	659,677	691,077	758,434	788,771	765,000
	(%)	4.4		7.4			18.6
Nigeria	**NERICA**					186,000	244,293
	RICE	2,185,000	2,210,000	2,348,000	2,725,000	2,451,000	1,836,880
	(%)					7.6	13.3
Uganda	**NERICA**		6,000			35,000	
	RICE	80,000	86,000	93,000	113,000	119,000	86,000
	(%)		7.0			29.4	

*calculated based on quantities of seed produced and distributed of farmers
(Sources: Author's compilation, based on Diagn *et al*., 2011; FAO STAT; Guei *et al*., 2008.; and JICA, N.A.)

On the other hand, Western African countries, such as Benin, Guinea, and Nigeria achieved less than 20 percent coverage; however, the actual size of rice cropping fields tended to be larger. This is because, in SSA, rice has been subsistence crop in West Africa and cash crop in East/South Africa. In terms of adoption rate, it shows that West African countries tend to adopt NERICA more (Table 2). In addition to the area under NERICA and the adoption rate, some research refers to the driving factor of NERICA adoption.

Table 2 Adoption of NERICA varieties (%)

		2000	2001	2003	2004	2005	2006	2008
Benin					19			
Cote d'Ivore		4						
Gambia		2*	4*	8*	14*	24*	40	
Guinea			23					
Nigeria								20
Kaduna	**NERICA 1**					42		
	NERICA 2					14		
Ekiti	**NERICA 1**					30		
	NERICA 2					9		
Uganda			0.9	2.9	16.5			

*the study revealed that the sample adoption rate does not consistently estimate the true population adoption rate under incomplete diffusion of a new technology even if the sample is randomly selected.
(Sources: Author's compilation, based on Dontsop *et al*., 2011; Diagn *et al*., 2011; and Dibba *et al*., 2012.)

For instance, in Gambia where achieved the highest adoption rate, to increase the adoption rate, "an important factor was exposure to NERICA through 'NERICA village' (adoption of NERICA in a whole village) (Dibba *et al*., 2012)," thus, creation of NERICA village will promote adoption. However, the unavailability of data in Table 1&2 could explain how insufficient holistic study of NERICA is and how difficult to capture a big picture of NERICA adoption under status quo. In other words, the existing research on NERICA is generally based on the case studies, thus it could be inferred that the credibility of generalization which is made by each research is possibly low.

The mainstream research of NERICA from social science perspectives is the analysis on impact of NERICA adoption. Majority of the research concludes that, there are positive impacts on farmers after they adopt NERICA. A research paper published by the official

research center of NERICA, AfricaRice notes that "adaptation of NERICA has a positive impact on household consumption per adult including school expenditure for his/her children (AfricaRice, 2008)." For instance, in Gambia, "[s]ignificant differences in rice yields and income between the NERICA adapters and non-adapters. (Dibba *et al*., 2012)"

To observe the positive impact of NERICA, I would like to further introduce three major case studies form Benin, Guinea, and Uganda. In Benin, rice has not been a major stable food, though the consumption of rice has increased since 2000 (Figure 2). Since 2003, after NERICA adoption, the additional yield gain has been reported. Moreover, the adoption of NERICA has several features: 1) impact adaptation is higher for women than for men (Table 3), 2) adaptation of NERICA resulted in a increase in school education of children (Table 4), and 3) adaptation of NERICA has a positive impact on household consumptions, daily calories intake per adult and decrease in deficit (Table 4). However, the impact at the national level is limited due to low diffusion of NERICA (refer to Table 2) (Diagne *et al*, 2009; Diagne *et al*, 2011, and Guei *et al*, 2008).

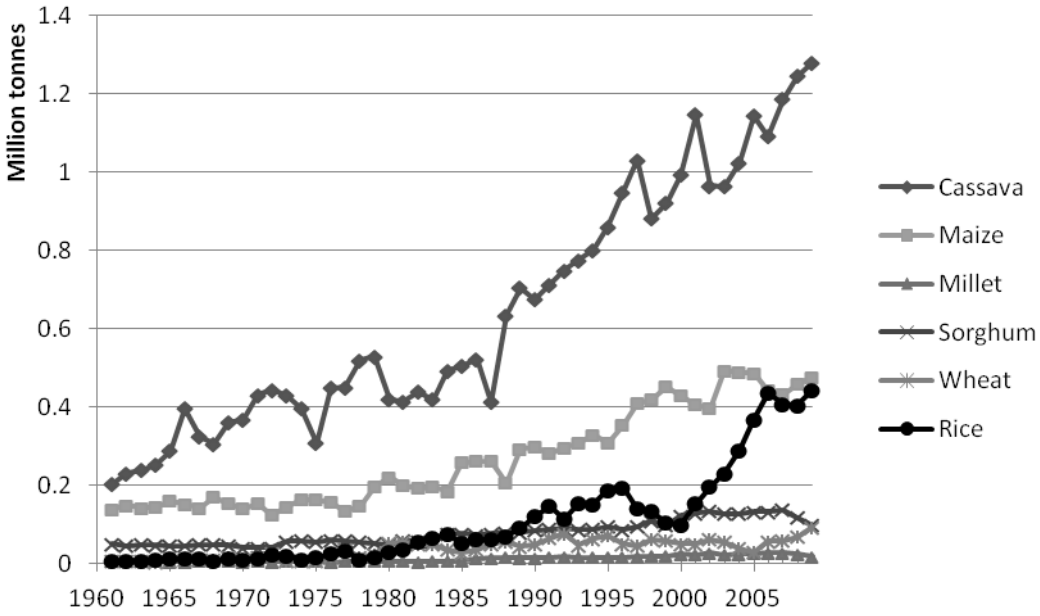


Figure 2 Food supply quantity: Benin

(Source: Author's compilation based on FAO STAT)

Table 3 The impact of NERICA adoption by gender in Benin (2004)

	Surplus of production (t/ha)	Additional income gain ($/ha)	Probability of being poor (%)
Men	0.52	227	-6
Women	0.85	337	-19

(Source: Author's compilation based on Diagne *et al*, 2009; Diagne *et al*, 2011; and Guei *et al*, 2008)

Table 4 Impact of NERICA adoption on selected Millennium Development Goal poverty indicators

Poverty indicator	Benin (2004)
Child school attendance rate	6%
Child school gender parity index	14%
School expenditure per child ($)	20
Total daily consumption expenditure per adult equivalent ($)	0.30
Daily calories intake per adult equivalent (Kcal/adeq)	36
Consumption expenditure deficit	-19%

(Source: AfricaRice, 2008)

In Guinea, rice is the important staple foods, and its consumption has been stably increasing as well as cassava (Figure 3). Similar to the features of Benin, positive impact of NERICA is

reported and the impact adaptation is higher for women than for men (Table 5). As it shown in the figure 3, since the rice consumption is large, NERICA is used by farmers to complement traditional varieties and thus enhance the varietal diversity of rice (AfricaRice, 2008 and Diagne *et al*., 2011).

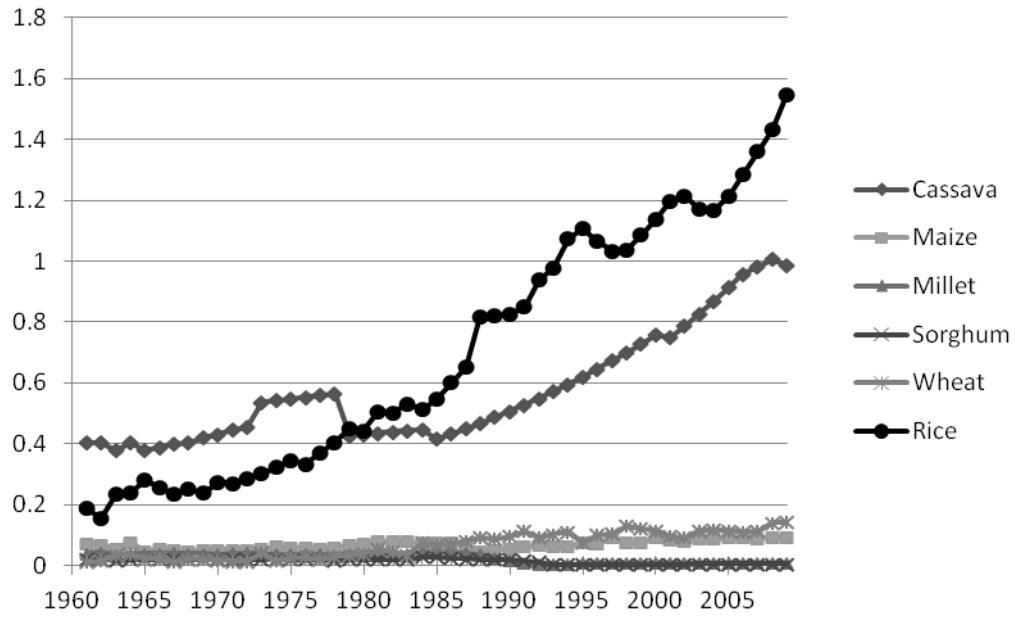


Figure 3 Food supply quantity: Guinea

(Source: Own graph based on FAO STAT)

Table 5 The impact of NERICA adoption by gender in Guinea (2006)

	Surplus of production (t/ha)	Additional income gain ($/ha)
Men	0.44	36
Women	1.09	660
Total	0.49	--

(Source: Author's compilation, based on AfricaRice, 2008 and Diagn *et al*., 2011)

At last, in Uganda, the rice consumption is not high compared to the other crops such as cassava (Figure 4). This is because Uganda is located in East Africa where rice is historically

a cash crop, though in terms of the adoption rate, it has been rapidly increasing (refer to Table 1 & 2). The case studies of NERICA in Uganda have been developed by Kijima and she interprets that NERICA has positive effects on productivity and allows farmers to improve their yields (average yields 1.7t/ha(2004) and 2.2t/ha(2005)—twice the average yield in SSA). Moreover, the adoption of NERICA has the potential to increase annual per capita income by $20 (12 percent of actual per capita income) and to reduce poverty by five percent, and importantly, introduction of NERICA decrease poverty to a significant extent without deteriorating income distribution (Kijima *et al*., 2006 and Kijima *et al*., 2008).

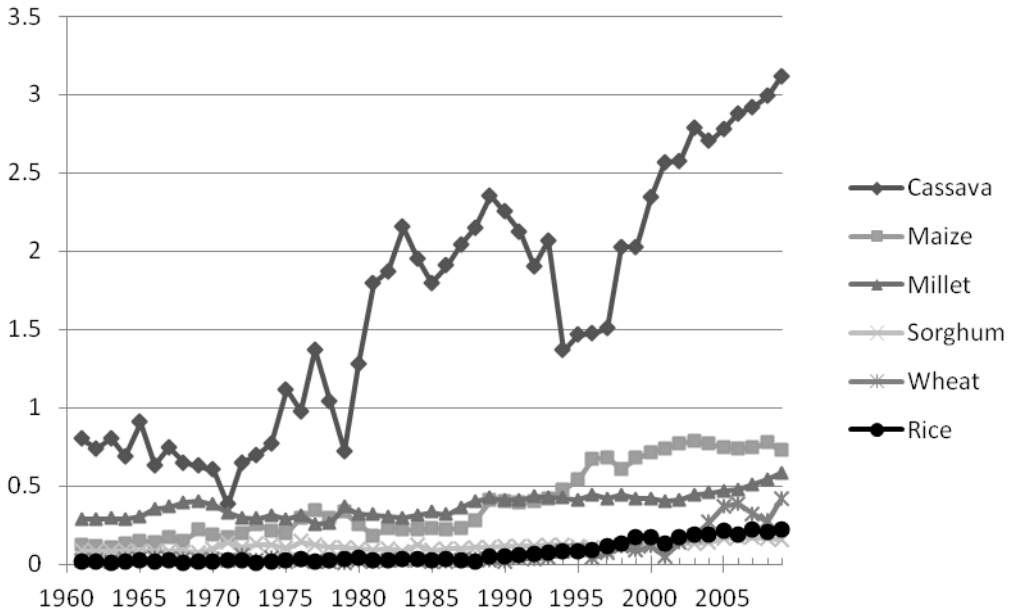


Figure 4 Food supply quantity: Uganda
(Source: Author's compilation based on FAO STAT)

From those three case studies from Benin, Guinea, and Uganda, a negative impact due to the NERICA adoption has not been documented so far. Hence, although the NERICA

adoption is limited, NERICA has been responding to the expectations of 'long promised green revolution in rice,' 'boosting rice yields and making Africa self-sufficient in rice production (Grain, 2009),' and 'contributing to poverty alleviation and food security in Africa (AfricaRice[3]).'

Why, then, is the NERICA's adoption rate low? Several studies point out the limited resources in SSA as a reason for NERICA's limited adoption. In terms of the research on the stagnation of the NERICA adoption, numbers of existing study becomes even smaller (Orr *et al*, 2008), particularly the research which academically testifies the causes of low NERICA adoption. Major criticisms of and suggestions for NERICA can be divided into three issues: 1) environmental constrains, 2) capability of the public sector and 3) capability of farmers and agricultural facilities (i.e. lack of agricultural and social infrastructures, lack of research capacity, low awareness by farmers, and low management skills of farmers). As for the first environmental constrains, researchers have made a conclusion based on their empirical observations such as "due to serious soil deterioration, it requires a large amount of fertilizers in order to recover the soil (Ito, 2006b)." (In terms of technology transferring and innovation in general, environmental constrains are quantified and theoretically analyzed and this will be discussed in 1.3.3 Environmental constraints) Similar tendencies of making conclusion could be found in the studies on capability of the public sector and low NERICA adoption such as lack of social infrastructures, farming skills, agricultural facilities, management skills (Kijima

[3] AfricaRice homepage, http://www.africarice.org/warda/aboutus.asp

et al., 2008; Diagn et al., 2011; Ito, 2006a; Saito, 2008; Yoneyama, 2006). Those findings might be the facts observed in the field of NERICA adoption, however, the causal relationship between the facts and the NERICA adoption has not been yet proven. The representative studies for the capability of farmers and agricultural facilities are: "poorly developed social infrastructure (especially irrigation system) (Akintayo *et al*, 2006 and Takane, 2006)," "farmers are often new to rice (except west) so that they do not have skills or agricultural facilities. (Kaneda, 2006)," "certain numbers of non-continuous adapters after PVS[4] due to low profitability compares to the alternative crops (Kijima, 2009) and lack of social infrastructures causes low accessibility of improved rice varieties. (Kijima *et al*., 2008)," and "low NERICA awareness is found to be a major constraint to NERICA adoption (Diagn *et al*., 2011)." Again, those studies identifies the facts found in the each case study, the causal relationships remain unproved except for the study on low awareness of NERICA by Diagn *et al* (2010).

Hence, although I have to acknowledge that there is a few exception, I believe those criticisms and suggestions are insufficient to ascertain the cause(s) of low adoption of NERICA for three reasons: 1) short of theoretical analysis of low NERICA adoption and empirical approaches based on case studies; those criticisms and suggestions have been made based on individual case studies in particular research fields. Therefore, they are too

[4] Participatory Varietal Selection (one procedure to spread NERICA to farmers), refer to 4.1 introduction, page 53

microscopic and empirical to reveal the reality of the whole NERICA adoption countries in SSA. In other words, the linkage between conclusion and suggestions are empirical, not theoretically proven. 2) Only shortcoming of developing countries identified as a cause; generally, failures of international aid are not only attributable to LDCs (recipients) but also developed countries and international agencies (donors). However, in terms of adoption of NERICA, research about donor sides has been sparse so far. 3) Proposed solutions to increase NERICA adoption are unrealistic such as improvement of social infrastructure.

Therefore, this research aims to indicate 1) the possible reason(s) semi-dwarf wheat was successfully adopted and NERICA was not, and 2) the cause(s) that donor sides have, other than what recipient sides do, at a macro level concerning theoretical/sociological aspects. For further clarification of my research goals, it is important to note that this research does not aim to prove whether GR and NERICA are successful cases for increasing food security. Rather, this research assumes that there are de facto differences in adoption of two different MVs, and the cause(s) of the differences will be an important lesson that should be learned in adding value when the next MVs are implemented in the future.

1.3 Summaries and Limitations of Past Modern Varieties Studies: Natural Science Perspectives

1.3.1 Semi-dwarf wheat during Green revolution in Mexico, India, and Pakistan

Semi-dwarf wheat is a short stem hybrid cross-breeding wheat with higher yields and resistant for lodging, thus, it is called high yielding variety/ HYV (this study calls it *modern varieties/MVs*). Historically, varietal improvement usually has had three major component: introduction of varieties from foreign countries; selection from introduced varieties; and hybridization (creation of new varieties by crossing), and all semi-dwarfs are the result of hybrid cross (Dalrymple, 1980). "Semi-dwarf is a plant which has a distinctly shorter stalk than traditional varieties and this shortness is brought about by a specific gene or set of genes that can be identified in genetic test (Dalrymple, 1980)." The reason that the semi-dwarf became significant in the agricultural research and international development fields in the 20th century is the introduction of chemical fertilizers for higher yield of the grains;

> The need for drastically shorter and more lodging resistant […] wheats had become apparent after growers began […] applying unusually heavy amounts of nitrogen fertilizers. Often accompanying the resultant high grain yields was severely lodged grain. […] Being aware of our lodging problems, [researchers] sent a collection of semi-dwarf wheats for preliminary observations (Vogel, 1977).

Thus, development of semi-dwarf wheat was perceived as an appropriate procedure to increase the wheat production in LDCs after WWII, and American scientist, Norman Borlaug

had started to develop semi-dwarf wheat in Mexico at first time in LDCs (after the successful adoption of semi-dwarf wheat in Mexico, it was transferred to India and Pakistan). The process of development of semi-dwarf wheat by Borlaug as follows:

> Borlaug began by tackling stem rust, a highly contagious mold-like fungus that breeds on a variety of grasses and transfers to wheat just as it comes to maturity. Stem rust could ruin entire fields of wheat at once. After extensive testing, [his research group] discovered that while foreign varieties were more resistant to stem rust than native wheat varieties, foreign varieties tended to mature late in the season. Furthermore, higher-yielding wheat varieties were more rust-susceptible than lower-yielding ones. [His research group] made three key discoveries. First, enhancing soil, particularly through nitrogen supplementation, increased wheat yield even with ongoing stem rust problems. Second, to make new hybrid crosses, in 1945 Borlaug began "shuttle-breeding," [which] cut development time in half and fostered varieties that could thrive across a variety of conditions. Finally, Borlaug began working with "Norin" dwarf wheat imported from the U.S., a short straw variety that was both rust-resistant and higher yielding (The Rockefeller Foundation[5]).

Then, what are the genetic origins of those early hybrid varieties? As it mentioned in the quotation above, the early varieties had a feature of highly resistant to the disease, and after Japanese variety, *Norin* series were introduced, the yields of semi-dwarf wheat dramatically increased. Borlaug notes that;

> We had recognized the barriers on yield imposed by lodging as early as 1948, but we had been frustrated in our search for a useable form of dwarfness to overcome this problem until the discovery of the so-called Norin dwarfs. In 1953 we received a few

[5] Rockefeller Foundation homepage: Agriculture, Mexico http://rockefeller100.org/exhibits/show/agriculture/mexico

> seeds of several F, selections from the cross Norin 10 X Brevor from Dr. Orville Vogel. […] A second attempt in 1955 was successful, and immediately it became evident that a new type of wheat was forthcoming with higher yield potential." The introduction of the Norin 10 genes led to the development of a number of Mexican dwarf and semi-dwarf bread wheat varieties: Pitic 62, Penjamo 62, Sonora 63, Sonora 64, Mayo 64, Lerma RoJo 64, Inia 66, Tobari 66, Ciano 67, Norteno 67, and Siete Cerros. (Dalrymple, G. D, 1974)

Hence, precisely, semi-dwarf wheat objected in this research contains a wide range of varieties: from Mexican wheat, the early high yielding varieties which had high resistant to the stem rust disease to Norin10-Brevor varieties with short stem.

Those series of semi-dwarf wheat were adopted in Mexico, India, and Pakistan rapidly and widely. Internationally, such initial wave of MV releases was highly evaluated. This was because modern varieties wheat generally took only 10 years to achieve about 50 percent area in Latin America and Asia in 1960-1970. Moreover, within 30years, it achieved more than 80-90 percent area planted to modern varieties of wheat (Figure 5).

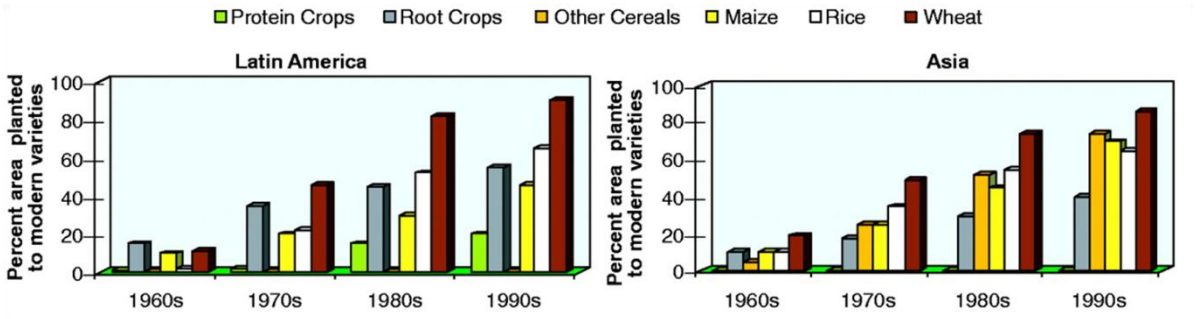


Figure 5 Modern variety diffusion by decade and region

(Source: Evenson and Gollin, 2003)

Looking at the annual data of MV wheat adoption by each nation, the data presents the conspicuous achievement. Although the annual data in Mexico in the 1950s is not available, it was reported that semi-dwarf wheat was heavily planted and it covered 60-90 percent of the agricultural land (Dalrymple, 1974). As a result, although Mexico imported 50 percent of wheat in 1940s, the subsistence level of wheat production was achieved in 1956. In 1964, Mexico started exporting 500,000 tons of wheat and it profited the farmers about $8,000,000 in total (Brown,1971). In addition, more data is available for the cases of India and Pakistan (Table 6), and they achieved more than 50 percent coverage of semi-dwarf wheat within 5-7 years. When it is compared to NERICA which achieved only 5 percent within 10 years, those percentages could explain how rapidly and widely semi-dwarf wheat adopted during GR.

Table 6 Semi-dwarf wheat area planted/harvested (1,000ha) and its ratio

		1965	1966	1967	1968	1969	1970	1971	1972	1973
India	Semi-dwarf	3	517	2,703	4,046	4,918	6,480	7,861	10,237	11,496
	Wheat	13,422	12,572	12,838	14,998	15,958	16,625	18,240	19,138	19,463
	(%)	0.02	4.11	21.06	26.98	30.82	38.98	43.10	53.49	59.06
Pakistan	Semi-dwarf	5	103	728	2,427	2,681	3,128	3,286	3,338	-
	Wheat	5,318	5,155	5,344	5,983	6,160	6,229	59,778	5,797	5,971
	(%)	0.09	2.00	13.63	40.57	43.53	50.22	54.98	57.60	-

(Source: Author's completion based on FAO STAT; Brown,1971; Dalrymple, 1974)

1.3.2 NERICA in contemporary SSA

Since NERICA's adoption rate has been already discussed, this part focuses on the claims of biological features of NERICA. NERICA varieties developed by the Africa Rice Center (AfricaRice) and partners from crosses between the Africa species *Oryza glaberruma Seud.* And the Asian species *O. sativa L*., using conventional biotechnology to overcome the sterility barrier between the two species. NERICA is a combination of the best traits of both parents; tolerability to the biotic stresses (i.e. rice diseases, insect attacks, and weeds) and abiotic stresses (soil acidity, drought, salinity, and iron toxicity) of African environment from African parent, and high yielding from Asian parent (Guei, 2008 and Diagne *et al*, 2011). There are currently 18 upland varieties (NERICA1 to NERICA18) and 60 lowland varieties (NERICA-L1 to NERICA-L60) and each variety has different identification and characteristics (i.e. agronomic, morphological, and organoleptic and technological), thus, farmer could choose the most suitable varieties for their fields and climates. For example, table 7 shows the distribution of upland NERICA varieties.

Table 7 Upland NERICA varieties released and adopted in SSA as of December 2006

NERICA Country	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Total per country
Benin	A	A	A																3
Burkina Faso												R	R		A		R	A	5
Congo Brazza										A									1
Congo DRC				A		A	A												3
Côte d'Ivoire	R	R	A	A	A														5
Ethiopia	A	A	R	R															4
Gambia	A	A	A	A	A	A	A												7
Ghana	R	A																	2
Guinea	R	R	R	R	R	R	R												7
Kenya	A		A							A	A								4
Mada-gascar		A	A																2
Mali				R					A	A				A				A	5
Nigeria	R	R																	3
Sierra Leone	A	A	A	A	A														5
Sudan				A			A												2
Togo	A		A	A															3
Uganda	A		A	R															3
Total	**11**	**9**	**10**	**10**	**4**	**3**	**4**	**0**	**1**	**3**	**1**	**1**	**1**	**1**	**1**	**0**	**1**	**2**	

R-frequency of release of NERICA varieties(19); A-frequency of NERICA adoption (44) and grown by farmers through might not be officially released in the country.
(Source: Guei *et al*, 2008)

The development of diverse NERICA varieties was attributed to the diverse biomes in SSA. For example, in the West and Central Africa region (from west to east, Guinea, Sierra Leone, Liberia, Cote d'Ivoire, Ghana, Togo, Nigeria, and Cameroon, and comprises some 40 million hectares), "[AfricaRice] has grouped the different crop environments of the region into six agro-ecological zones, defined by the following criteria: climate, vegetation, soil, cropping pattern, and altitude. The [agro-ecological zones] are: Rain Forest, Derived Savanna, Northern Guinea Savanna, Southern Guinea Savanna, Sudan Savanna and Sahel (WARDA and FAO,

2002).” (Figure 6) In terms of lowland ecology, it “is sub-divided into three types: Rainfed, Mangrove Swamp, and Irrigated. Thus, the four ecologies found in West and Central Africa are: rainfed upland, rainfed lowland, irrigated lowland, and mangrove swamp (WARDA and FAO, 2002).” Thus, those climatic factors affect the distribution of different NERICA varieties.

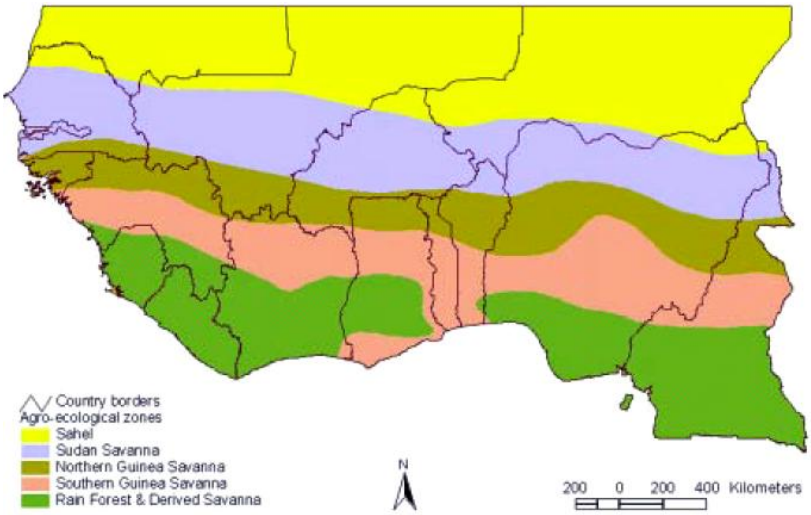


Figure 6 Agro-ecological zones of West and Central Africa
(Source: WARDA and FAO, 2002)

At last, other features of NERICA (other than its high yield), according to the AfricaRice NERICA manual, are “short growth cycle: several of them possess early vigor during the vegetative growth phase and this is a potentially useful trait for weed competitiveness. Likewise, a number of them are resistant to African pests and diseases, such as the devastating blast, to rice stemborers and termites. They also have higher protein content and amino acid balance than most of the imported rice varieties. (Guei, 2008)” The table 8 below summarizes the important information of semi-dwarf wheat and NERICA.

Table 8 Summaries of modern varieties

	Green Revolution	NERICA-SSA
Selected countries	Mexico, India, Pakistan	32 SSA countries
Selected varieties	Semi-dwarf wheat (Mexican varieties; including early high-yielding varieties/HYV)	NERICA (19upland varieties and 60 lowland varieties)
Developed as a new variety	1946-1967*	1994
First adoption of modern variety to farmers	Mexico: 1946/1961** India: 1965 Pakistan: 1965	Guinea & Côte d'Ivoire: 2001
Features	-short stem to avoid lodging -high chemical fertilizer response -high yielding along with input	-high resistant to Africa's abiotic and biotic environment -higher yielding without input or irrigation -short growth cycle -high protein

*new genetic varieties were continuously developed
** first high yielding variety was introduced in 1946 and first semi-dwarf wheat was introduced in 1961.
(Author's compilation based on Bickel, 1974., Guei, 2008., Gridley *et al*, 2002., Dalrymple, 1974., Diagne *et al*, 2011., Hesser, 2009.)

1.3.3 Environmental constraints

Having explained summary of both semi-dwarf what and NERICA, this part refers the discussion of environmental constraints of both semi-dwarf wheat and NERICA, because among all advanced technologies, agriculture is claimed as most difficult technologies to transfer and develop for instance, in the temperate zone to the tropical zone since they are strongly constrained by environment (Hayami *et al*, 2005). Thus, when NERICA is compared to the GR, the causes of NERICA stagnation are often converged to its environmental constraints. In general, the two biggest environmental constraints that are claimed by researchers and scientists are climates and irrigation systems. When semi-dwarf wheat is exported from Mexico to India/Pakistan, due to the similarity of the territorial biomes and

ecology, a large improvement in MVs was unnecessary and Mexican semi-dwarf wheat was implemented in India/Pakistan as well. Moreover, Mexico, India, and Pakistan had a long history of cultivating wheat, thus, farmers could accept MVs without crucial psychological and physical resistance. Therefore, relatively fewer obstacles existed to spread MVs during GR.

However, in SSA, climates and irrigation systems are interrelated, and they are significant challenges for farmers. This is because, to introduce MVs in the extreme climates of Africa, farmers need appropriate irrigation systems. In SSA, the climate is unstable and it is not rare to have a drought and a flood in the same year (Yoneyama, 2006). Moreover, the dry areas of the African continent are notably vulnerable to climate change, and desertification becomes a serious issue. Last, but not least, as it was mentioned previously, the African continent is vertically and horizontally large so terrestrial biomes are diverse from rain forest to savanna and dessert. Therefore, to benefit all the farmers in SSA, new NERICA varieties must be adapted to the unique environment of each country or region. To meet diverse rice growing ecologies, about 80 NERICA varieties have been developed (Guei *et al*, 2008), and each SSA country adopts the varieties that suit their climates and ecologies. The scientists dedicate their efforts to tackle those environmental constraints and together with difficulties to have appropriate irrigation systems, they become the obstacles to promote NERICA. By acknowledging those differences in the environmental constraints between semi-dwarf wheat

and NERICA, this research omits those environmental factors from the discussion and develops analysis on the internal factors.

1.4 Objectives of this Study

This research aims to clarify the possible cause(s) of low adoption of NERICA in SSA from sociological/theoretical aspects. Moreover, by clarifying the cause(s) of stagnation of NERICA adoption, this research provides a lesson for the implementation of future MVs, and contributes to increasing food security and eradicating poverty in LDCs.

In this research, GR refers to the development and implementation of semi-dwarf wheat which is one of the MVs introduced in Mexico, India, and Pakistan, and excludes all other MVs such as rice, to focus on the early stage of MVs adoption for both semi-dwarf wheat and NERICA. This research testifies that ‘how does the implementation of the modern variety wheat and NERICA differ?’

2 METHODOLOGY

I hypothesize that implementation system of MVs is a major cause of the different adoption rate (other than environmental constrains), because the implementation systems are highly influenced by the donors (i.e. developed countries and international agencies) and the more differences could be found in the international social conditions rather than domestic social conditions. Moreover, Green Revolution achieved high adoption rate because MVs research, development, and expansion demonstrated more efficient and suitable features so called organic (non-bureaucratic) forms although the implementation system itself was a typical top-down model when it is shown by the organization chart whereas NERICA demonstrates the opposite features.

In this study, I define the implementation system of MVs as *research*, *development*, and *expansion* (deployment) of MVs, and this excludes either expansion process done by recipients/LDCs or extension and advisory services that both are major factors to be discussed by researchers from the fields of technological transferring and innovation. The *expansion* refers to the process done by donors who are in the upstream position of the whole expansion process to reveal issues of donor sides. The concept of extension and advisory services refers to facilitation of "the access of farmers, their organizations, and other value chain and market

actors to knowledge, information, and technologies (World Bank, 2012),” and this is also excluded because ‘agribusiness and NERICA’ is another big topic and including this topic may cause incoherence and unfocused research.

As for the structure of this study, it has the three phases of analysis through literature/document reviews based on secondary data: analysis on domestic social conditions, international social conditions, and implementation system of MVs by assuming that semi-dwarf wheat is a successful case in terms of the adoption rate.

The first analysis discusses the domestic social conditions in Mexico, India, and Pakistan in the 1940s-1960s and SSA countries in the 1990s to present, since the cause(s) of NERICA stagnation could be attributed to the implementation system, if the domestic social conditions (that are the driving factors to promote MVs adoption) demonstrate similar tendencies. Moreover, based on the preliminary study, I would say that surrounding conditions for adoption of semi-dwarf wheat were much tighter than the adoption of NERICA; to adopt semi-dwarf wheat, production costs increased for pesticides, herbicides, and chemical fertilizers by 60 percent and they were additional burdens for the poor small-scale farmers (Bickel, 1974). Contrarily, NERICA promises high yield advantage and local resistance without chemical fertilizers/pesticide/herbicide. In short, biologically NERICA performs better than the semi-dwarf wheat.

The second analysis focuses on the historical background of international society. Since

development and implementation of MVs cannot be achieved without international cooperation, it is anticipated that the differences at the international level are directly reflected to the differences of both implementation processes of semi-dwarf wheat and NERICA. Hence, this section not only discusses the international phenomena and trends, but also analyzes how those are related to the implementation process.

The third analysis focuses on the implementation system of both varieties by applying the observations shown in the organization theory by Burns & Stalker (1961). This analysis aims to verbalize and contextualize the 'differences' to facilitate emerging the solutions to NERICA stagnation and further exploration for efficiency of MVs adoption.

Finally yet importantly, the legitimate premise that I compare and contrast semi-dwarf wheat and NERICA is that background of both varieties shares similarity: semi-dwarf wheat and NERICA are both represent and leading agricultural technology for two different time periods and geographic regions. On the other hand, for example, modern variety rice in Asia that is the best known as GR, it could not be a target for the comparison with NERICA. This is because the modern variety rice has been introduced and adopted in 1970s with the backing of the success story of semi-dwarf wheat in 1960s, hence, donors and LDCs were ready to accept the modern variety rice and confident for the success of its adoption, even before it was introduced. Therefore, the comparison of semi-dwarf wheat and NERICA is significance to reveal the differences in the implementation process from the sociological/theoretical aspect.

Again, I would like to emphasize that this study will be focusing on the cause(s) of low adoption, rather than the merits or demerits of NERICA and MVs, thus, the story of NERICA is just one example to explore the process of MVs adoption.

3 ANALYSIS ON DOMESTIC SOCIAL CONDITIONS

3.1 Introduction

In this section, three domestic social conditions in all selected countries (Mexico, India, Pakistan, and SSA countries) are examined. Since the Modern Varieties (MVs)—semi-dwarf wheat and NERICA share the features of high yields, and potential of increasing food productivity and eradication of hunger, three domestic social conditions (*hunger and poverty*, *population pressure*, and *demand on same species grain as MVs*) could be defined as a driving factor of MVs adoption. However, I could not find significant differences between semi-dwarf wheat and NERICA in those three factors. Therefore, this analysis validates that those three factors are not important causes of NERICA stagnation.

3.2 Methodology

Specific methodology to analyze the domestic social conditions in the selected countries is data collection mainly from the reports and databases of international organizations based on the hypothesis of the domestic social conditions demonstrate the similar tendencies and the cause(s) of NERICA stagnation mainly originating from the international social conditions, not from the domestic social conditions. To measure the

hunger and poverty trend, I use the malnutrition rates of each country from FAO and World Bank reports. Since the data of malnutrition rate is partially unavailable, I also utilize the under-five mortality rate as a supplemental data from UNICEF statistical table. As for population pressure, I prepare the arable land area and population for each country from FAO STAT, and conduct calculation to find arable land per capita. To illustrate the demand for grains, I apply the data of imports, production, and consumption from FAO STAT and USDA reports. Those three analyses are to testify the possible driving forces of implementation of semi-dwarf wheat during the Green Revolution (GR) and Sub-Sahara Africa (SSA).

3.3 Results and Discussions

3.3.1 Hunger and poverty

It is imaginable that contemporary SSA has been experiencing chronic hunger. Historically, Latin America and Asia also have been experienced severe famine. To analyze hunger and poverty issues in the selected countries inclusively, this part firstly focuses on the history of global food security issues of the post-WWII period (1945-), and then, discusses how GR and contemporary SSA share the similar hunger and poverty tendencies.

In the post-WWII period, global food security issues have gone through an unstable transition. How, then, were those transition related to the food shortage in Latin America and India? Saito well answered to that question:

As it is summarized below, from right after WWII to early 1950, the total amount of foods that were produced was insufficient to feed the world's population. It was the global food shortage until the end of Korean War that had increased demands on food. In 1953, the food shortage shifted to a food glut and continued until the end of the 1950s. However, in the beginning of the 1960s, the amount of food stocks started to decrease and after the middle of the 1960s, international society became concerned about the imminent food shortage. Sterile years and famines all over the world (China in 1959-1961, Soviet Union in 1963, India in 1965 and 1966, Burma in 1965 and 1966, Thailand in 1965 and Pakistan 1966) pushed international society back to the food shortage. Surprisingly, after India came back to high food productions in 1967, international society led by the US became optimistic about food security issues.

Food shortage:	-1952
Food glut:	1953-1959
Transition from food glut to food shortage:	early 1960s
Food shortage:	-1967
Food glut:	1968-

Those trends could be explained through the relationship between the amount of food stock and global trade volume (Figure 7). The graph shows the transition of the global trade volume of both wheat and coarse grains from 1954-55, food glut era to 1966-67, the early time of GR in Asia. Until 1961, the global trade volumes of the wheat and the coarse grains edged upwards. On the other hand, amounts of food stocks increased rapidly and peaked at 140 million tonnes[6] in 1960. However, after 1961, the stock decreased while trade volume increased, indicating that the international society faced a food shortage again. (Saito, 1972)

Those data describe how LDCs, especially India and Pakistan, faced inevitable food shortage at the domestic level during the time of GR.

Micro level analysis also clarifies how individuals actually experienced hunger. The predecessor of the present methodology that measures hunger and undernourishment by FAO has become common since 1990 (FAO *et al*, 2012), and thus, the data during the time of GR

[6] 1 tonne= 1000kg British version of 'tonne' is used to avoid confusion with the short ton (=2000pounds, 907.18474kg) and the long ton (=2,240 pounds, 1016 kg).

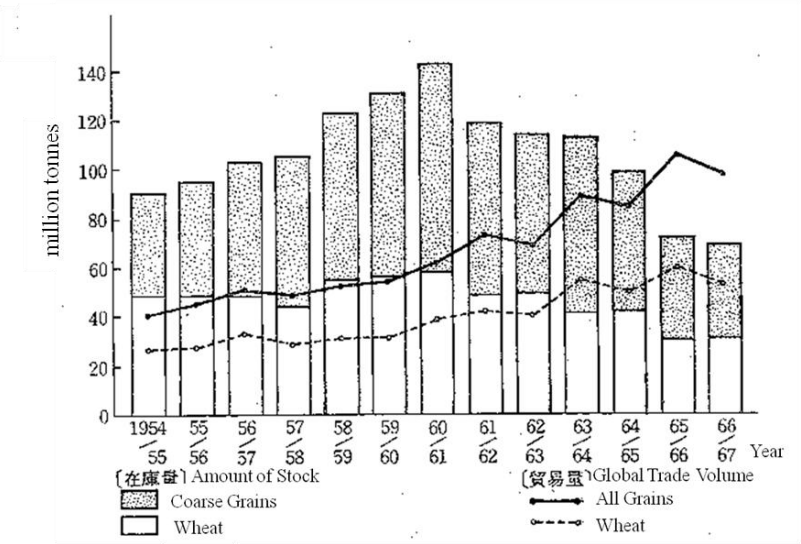


Figure 7 Global trade volume of grains and amount of grain stocks in major countries (except for USA)

(Source: Saito, 1972)

is limited. However, a report by the World Bank expresses evidence of malnutrition in Latin America and Asia at the time of GR (World Bank, 1994). The dietary deficiencies mean lack of vitamins and mineral [vitamin A, iodine and iron] that cause learning disabilities, mental retardation, poor health, low work capacity, blindness, and premature death. In the 1960s developing world showed serious vitamin and mineral deficiencies, though health care programs provided a necessary point of intervention, they cannot completely correct the causes (World Bank, 1994).

Food security in SSA is severely threatened at present. Although the comparison of the time of GR and NERICA is biased to some extent due to the usage of different data sets, similarities of hunger and poverty trends are comprehensive. Figure 8 illustrates that regional hunger trends and achievement of Millennium Development Goals (MDGs). Although MDGs

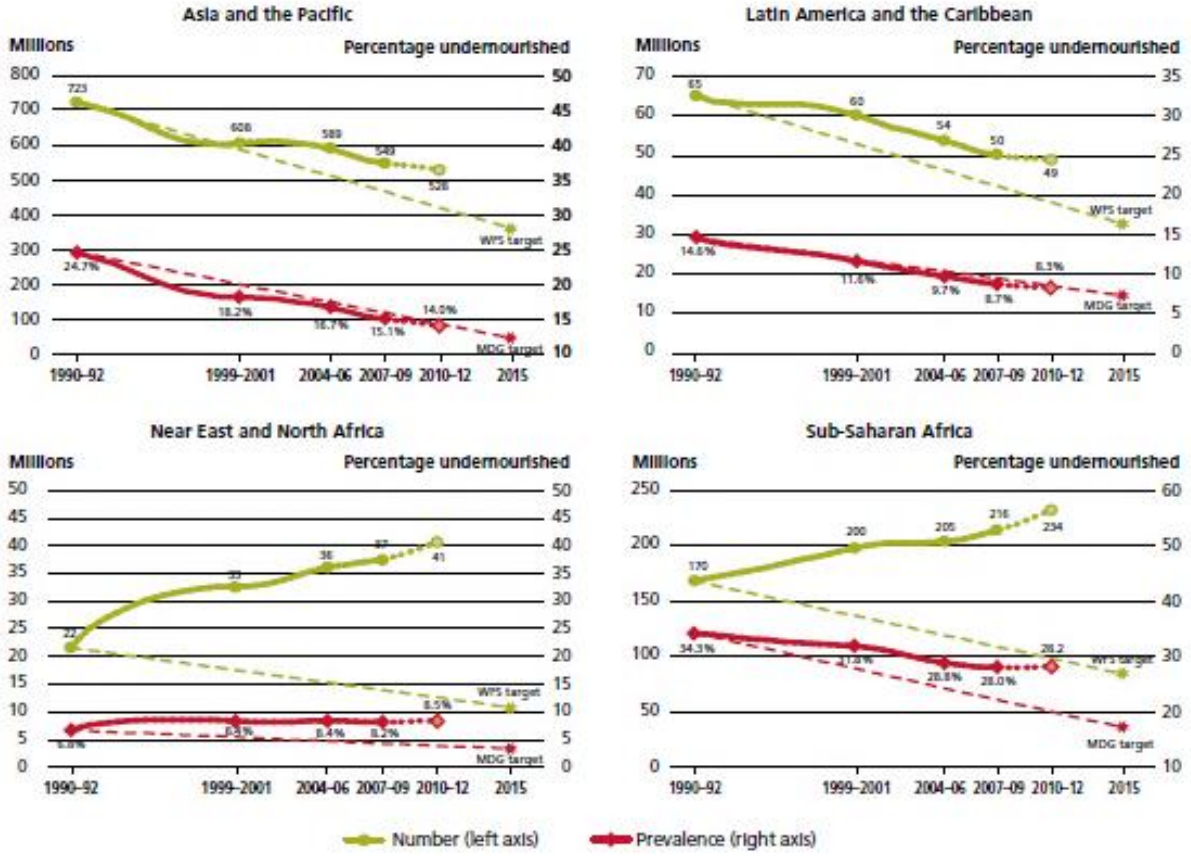


Figure 8 Hunger trends in the developing regions[7]

(Source: FAO *et al*, 2012)

declared eradication of poverty, the percentage of undernourished in SSA is more than 25 percent, and the number is still increasing whereas other regions such as Asia and Latin America show a clear tendency of reduction and achievement of MDGs.

Since the data that prove the trend of hunger and poverty for all selected countries are limited, here is another source that objectively shows hunger and poverty trends called the *under five mortality rate* (U5MR). U5MR is the probability per 1,000 that a newborn baby

[7]Unlike the data from the time of GR, methodology and data to indicate the undernourished population have improved. For more details about determining the undernourished, the document published by FAO defined that "[t]he FAO measure of food deprivation, which is referred to as the prevalence of undernourishment, is based on a comparison of usual food consumption expressed in terms of dietary energy (kcal) with certain energy requirement norms. The part of the population with food consumption below the energy requirement norm is considered undernourished ("underfed") (Naiken, 2003)."

will die before the age of five. This is often used to measure health issues in LDCs. At the same time, when U5MR is compared with the Gross National Income (GNI), U5MR represents tends to represent the countries' economical development based on the citizen's health condition; the higher the GNI is, the lower the U5MR becomes. The low U5MR and GNI (and vice versa) generally infer the large gap between the rich and the poor, and unequal accessibility to the health services (JAIH, 2001). Therefore, U5MR represents not only the health issue including the hunger issue but also the poverty issue of the LDCs. Furthermore, U5MR is unique for "[f]irst, it measures an end result of the development process rather than an 'input' such as school enrolment level, per capita calorie availability, or the number of doctors per thousand population -- all of which are means to an end, [s]econd, the U5MR is known to be the result of a wide variety of inputs, […] [t]hird, the U5MR is less susceptible than, say, per capita GNP to the fallacy of the average [and f]or these reasons, the U5MR is chosen by UNICEF as its single most important indicator (UNICEF, 1996)."

Figure 9 delivers the comparison of U5MR data from Mexico, India and Pakistan in 1960 just before the semi-dwarf wheat was implemented (as for Mexico, semi-dwarf wheat has been implemented in the late 1940s and became popular in the early 1950s) and other SSA countries in 1994 when NERICA was officially developed (but adoption by local farmers was limited). According to this data, in 1960, U5MR was 236 and 221 in India and Pakistan and even in Mexico 148 under-five children in 1,000 died (refer to Appendix A for the

specific numbers). Since U5MR of developed countries like Japan and USA is less than 10, those numbers clearly prove that their societies were much less secured in terms of health and economical development. SSA countries in 1994 did not demonstrate significant differences from Mexico and other countries. Most of the countries exceeded 150, and for those countries that are less than 150 were either 1994 was exceptionally low (Benin, Cameroon, Rwanda) or stabilized around 100 (Congo, Ghana, Kenya, Sudan, and Togo) (WHO Global Health Observatory Data Repository). Since GNI of those latter countries in 1994 were 2,150, 760, 980, 790 and 590 (WB data) so, based on lower economic development, it could be inferred that the society was stratified and a wide gap between the rich and the poor. The Republic of Congo showed higher GNI compared with those of other SSA countries, and this was explained by the mining industry and oil trade (MOFA Japan basic data). This country went through a conflict in 1997 and thus, it was also far from a secure society.

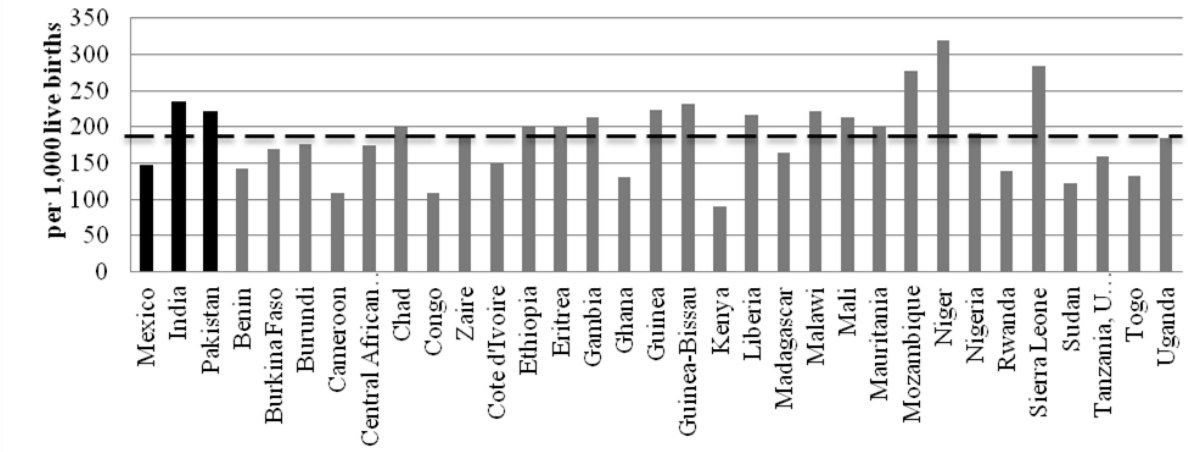


Figure 9 Under-five Mortality Rate (U5MR) : Mexico, India, and Pakistan in 1960 and others in 1994

(Source: Own graph based on UNICEF statistical tables, 1996, Appendix A)

Although the presented data about malnutrition and hunger are slightly biased due to the limitation of the available data, social conditions during the implementation period in Mexico, India Pakistan, and SSA show similar tendencies in terms of food security. Especially, food security at the international level in the 1950s-60s was unstable, and vulnerable countries were easily faced severe famine. Finally, U5MR clearly indicates that not only SSA, but also Mexico, India, and Pakistan experience low economical development that caused significant damages on children and ultimately on the societies.

3.3.2 Population pressure

Rapid population growth in LDCs is inevitable, and high population pressure is a major factor that accelerates the food shortage for the small scale and vulnerable farmers, and thus, it becomes one driving factor to promote development of MVs. In other word, the logic is that high population pressure equals to land shortage, consequently, cost of maintaining the land becomes higher due to the high demands on the land. Moreover, for the small farmers who do not own extra agricultural lands for fallow fields, they abuse their lands and as a result, the productivity of the lands also becomes lower. As a result, farmers fail to produce enough amounts of subsistence and cash crops. In that sense, population pressure and MVs are germane. From the perspective of technology transferring and innovation, “the Green Revolution can be viewed as a transfer of the mechanism for developing land saving

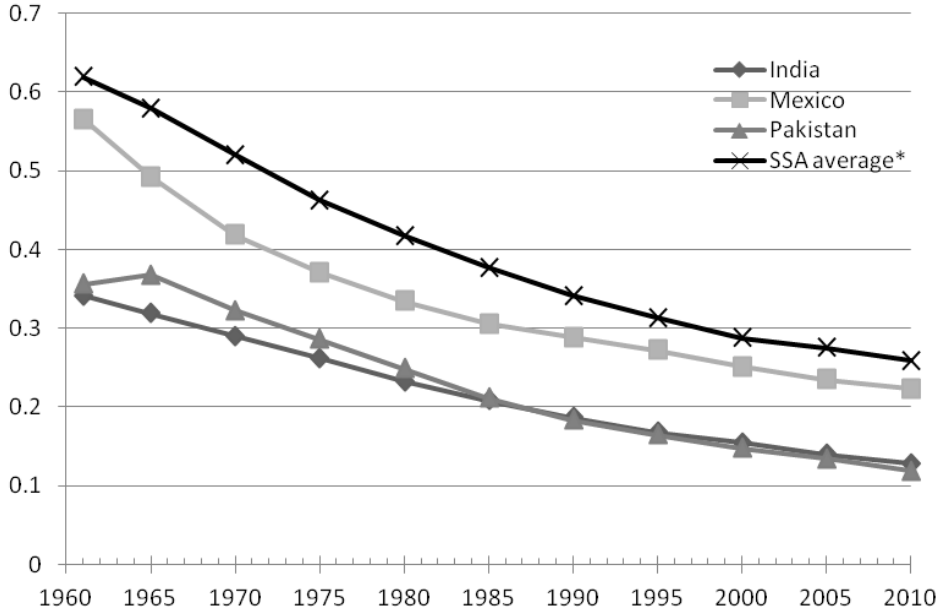
technologies (Hayami *et al*, 2005)," and MVs are included in the categories of the land saving technologies.

Table 9 lists an arable land[8] per capita in India, Mexico, Pakistan, and SSA. The data are calculated by dividing the national arable land area by the total population of each country. As the graph illustrates, arable land per capita is rapidly decreasing. Not only that, but also, at the point of the implementation phase of MVs (1961 in India, Mexico and Pakistan, and 1995/2000 in SSA), the arable lands per capita are similarly low. The arable land per capita in SSA is 0.341-0.313 ha (1995-2000), and 0.341-0.565 ha in India, Mexico, and Pakistan (1961). Although India, Mexico, and Pakistan demonstrate the high population pressure during GR, SSA shows the smallest arable land per capita and it explains that population pressure is the most severe in SSA compared with the time of GR. For instance, Niger showed the largest arable land per capita 1.524 ha, and Rwanda showed the smallest 0.111 ha in the year 2000 (refer to Appendix D). As for Rwanda, the reason for low arable land per capita was imaginable since one cause for the genocide in 1994 was land shortage. As for Niger, the result was attributed to its larger arable land compared with the total population: the third largest arable land among the all other SSA countries, while the total population was moderate

[8] *Arable land* is defined by FAO as the land under temporary agricultural crops (multiple-cropped areas are counted only once), temporary meadows for mowing or pasture, land under market and kitchen gardens and land temporarily fallow (less than five years). The abandoned land resulting from shifting cultivation is not included in this category. Data for "Arable land" are not meant to indicate the amount of land that is potentially cultivable (FAO STAT).

Table 9 Arable land per capita (ha)

	1961	1965	1970	1975	1980	1985	1990	1995	2000	2005	2010
India	0.341	0.319	0.290	0.262	0.233	0.208	0.186	0.168	0.154	0.140	0.129
Mexico	0.565	0.492	0.418	0.371	0.334	0.306	0.288	0.272	0.251	0.235	0.223
Pakistan	0.356	0.368	0.323	0.286	0.248	0.212	0.183	0.165	0.147	0.134	0.118
SSA average*	0.619	0.579	0.520	0.462	0.418	0.377	0.341	0.313	0.287	0.275	0.259



* Mean of Benin, Burkina Faso, Burundi, Cameroon, Central African Republic, Chad, Congo, Côte d'Ivoire, Democratic Republic of the Congo, Eritrea, Ethiopia, Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Liberia, Madagascar, Malawi, Mali, Mauritania, Mozambique, Niger, Nigeria, Rwanda, Senegal, Sierra Leone, Sudan (former), Togo, Uganda and United Republic of Tanzania.

(Source: own graph based on FAO STAT, Appendix B, C, and D)

among the others (Appendix D). Despite having the largest arable land per capita, food security has been vulnerable and faced severe famine in 2005 due to drought and damage from pests. Not only low food security, but also political instability has been an urgent issue because Niger has had repeated coup d'etats since 1996 until now (MOFA Japan basic data[9]).

Then, how decreasing arable land per capita related to the implementation of MVs? High population pressure changes the efforts of farmers to increase the amounts of products

[9]Basic data of foreign countries disclosed by Ministry of Foreign Affairs of Japan

from expanding the land to increasing the productivity based on new agricultural technologies. Development economics perspectives require an increasing yield of crops to produce the same amount of food as before (Watanabe, 2010). To achieve that, two augmentation processes are expected:

> Increasing land productivity through improvement of the irrigation system and seed-fertilizer technology are categorized as 'internal land augmentation,' and expanding cultivation frontier as 'external land augmentation.' As long as there is enough new land, marginal cost of opening new land is profitable so that farmers take advantage for external augmentation. However, as the cultivation frontier encroaches on inferior land, farmers starts to invest in land infrastructure because irrigation permits the introduction of new seed-fertilizer technology. Due to high complementarity, fertilizers and improved seeds have the effect of reducing the cost of irrigation and it increases the farmers' incentive to invest in infrastructure rather than expand the land, especially because the tendency of low response of public sectors so farmers need to establish irrigation facilities individually or by the community. (Hayami and Godo, 2005 and Hayami, 1995)

To add an aside, as a corollary of the relation with MVs and population pressure, Hayami and Godo concluded that high percentage of rainfed land (undeveloped infrastructure) makes it difficult for Africa to follow the Asia type GR (Hayami and Godo, 2005).

Their analysis was innovative and well explained in the sense of the relationship between MVs and population pressure. While admitting the aspect of Africa towards MVs, it should not be the only cause for NERICA stagnation; thus, this research focuses more on the facts that Hayami's analysis does not cover. In sum, high population pressure is observed in all countries that adopted MVs, and higher population pressure in SSA explains that the

population pressure which is one of the domestic social conditions is not a significant cause of stagnation of NERICA.

3.3.3 Demands for grains

Having partially explained the logic of MVs popularity among farmers based on development economics aspect, this part discusses the demands for the same species grain as MVs based on the logic of supply and demand. 'Supply and demand' in general, based on microeconomic perspective explains; if there is a demand, the price will increase and consequently, it becomes an incentive for the producers. In other words, if demand of wheat increases, it is comprehensible that farmers choose high productive wheat to produce more, and such tendency was observed during the implementation phase of GR. In terms of the causality between high demand for wheat and the adoption of semi-dwarf wheat has been under discussion and some studies argue GR was not a demand-driven production rather, supply-driven production (Delgado *et al,* 1999). However, unlike their studies, high demand for grain was observed for the case of NERICA and semi-dwarf wheat, hence, this part discusses the tendency of high demand of wheat during GR, and increasing demand of rice in contemporary SSA assuming that MVs are demand driven production.

Figure 10-13 illustrate the transitions of wheat demand in each country (India, Mexico and Pakistan). Since 1960, wheat consumption became larger than production, and imports

increased in India and Pakistan (Figure 10 & 13). The reason that Mexico did not show the similar tendency (Figure 11) was semi-dwarf was introduced in 1946 (1965 in India and Pakistan) and in the early 1950s, production of wheat in Mexico dramatically increased due to successful dissemination of semi-dwarf wheat. As a result, in 1956, Mexico achieved self sufficiency of wheat for the first time in its history (Bickel, 1974). However, as Figure 12 shows, before semi-dwarf wheat was introduced, Mexico was not exception for high demand of wheat (reliable data of imports could not be found).

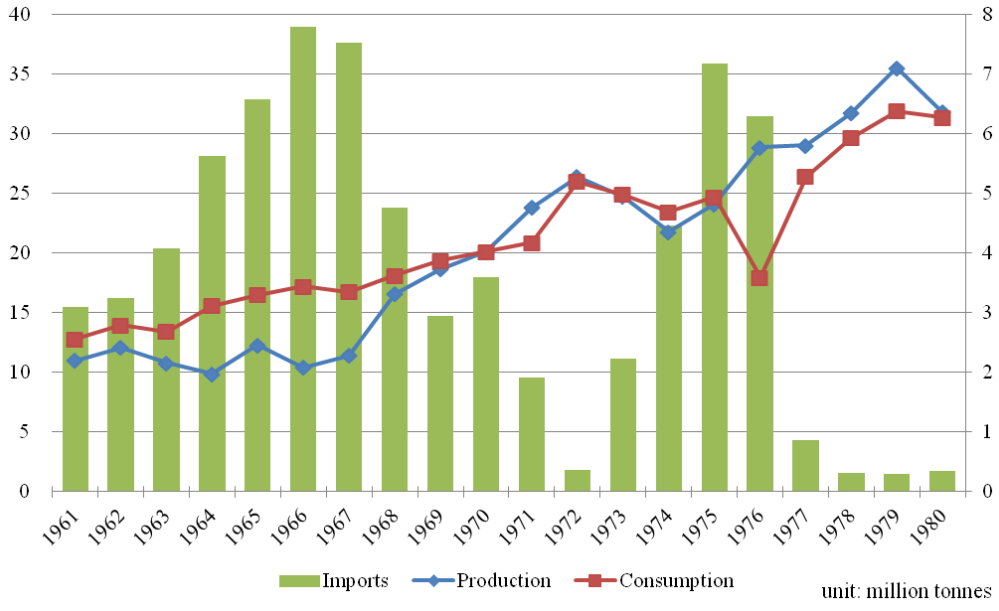


Figure 10 Wheat production, consumption[10] and imports in India

(Source: own graph based on FAO STAT)

[10]Consumption is indicated as *Food supply quantity* in FAO STAT. According to FAO STAT, food supply per capita (though the data used was total quantity of food supply) is "…estimates of per capita food supplies available for human consumption during the reference period in terms of quantity, caloric value, protein, and fat content. Calorie supplies are reported in kilocalories (1 calorie = 4.19 kilojoules).[…] it is important to note that the amount of food actually consumed may be lower than the quantity shown here, depending on the degree of losses of edible food and nutrients in the household (FAOSTAT)."

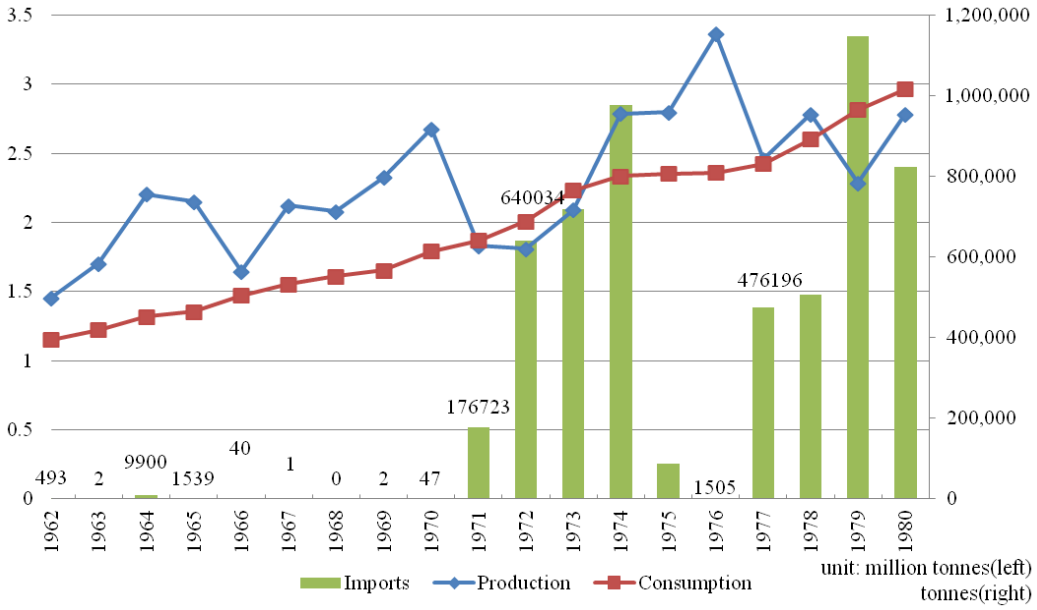


Figure 11 Wheat production, consumption and imports in Mexico

(Source: own graph based on FAO STAT)

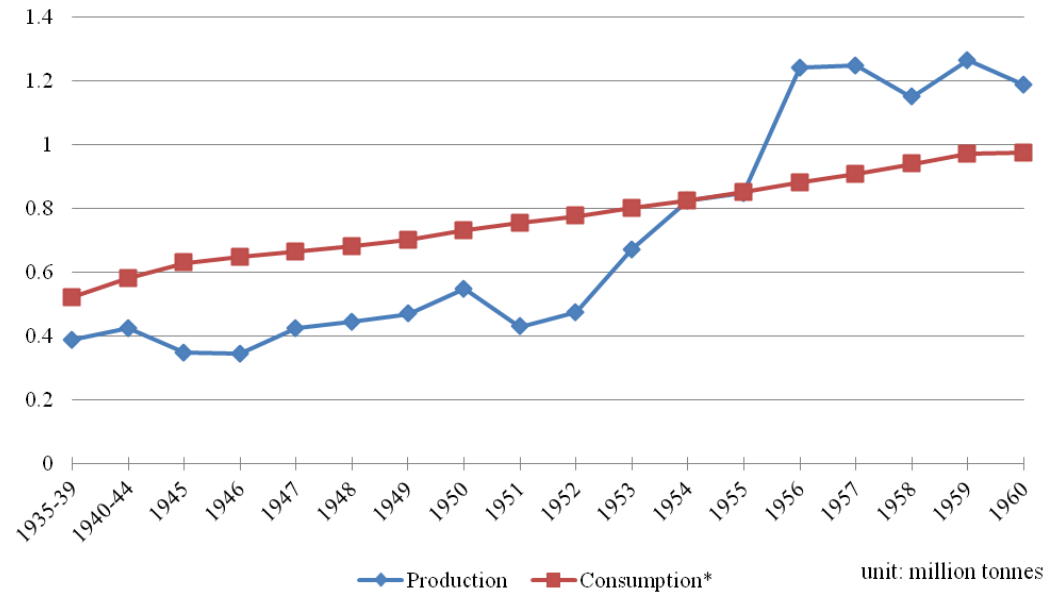


Figure 12 Wheat Production and consumption in 1935-1960 in Mexico

*Quantity of consumption estimated based on the data of consumption per capita in 1961.
(Source: author's compilation based on FAO STAT; Lahmeyer, 1999; and USDA, 1947, 1950, 1953, 1955, 1956, 1958a, 1958b, 1962a and 1962b.)

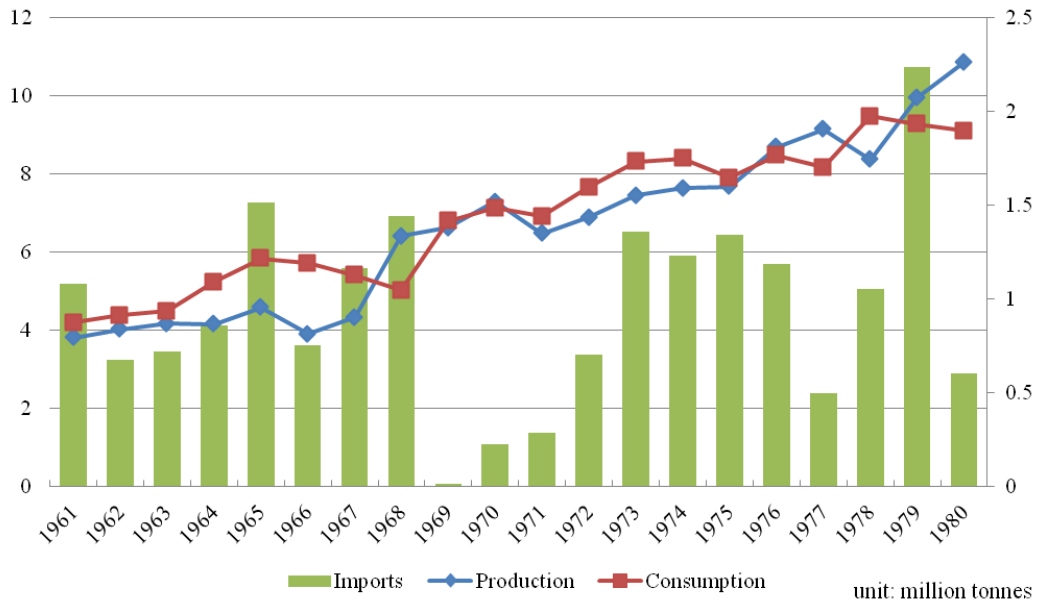


Figure 13 Wheat production, consumption and imports in Pakistan

(Source: own graph based on FAO STAT)

Increasing demand for rice in SSA is not a new issue. A paper published by AfricaRice, reports that "demand for rice in West and Central Africa has been growing at the rate of 6% per annum since 1973, and now amounts to over 8 million tonnes per annum (Gridley *et al*, 2002)." Actual data support the report; Figure 14 was based on available data from major SSA countries that adopted NERICA, and it demonstrates that imports and consumption outpaced production. In addition, a negative impact of importing rice was claimed by Seck; import rice costs 4 billion dollar that could have been invested in developing other sectors if it had been possible for SSA to produce enough rice by themselves (Seck *et al*., 2010).

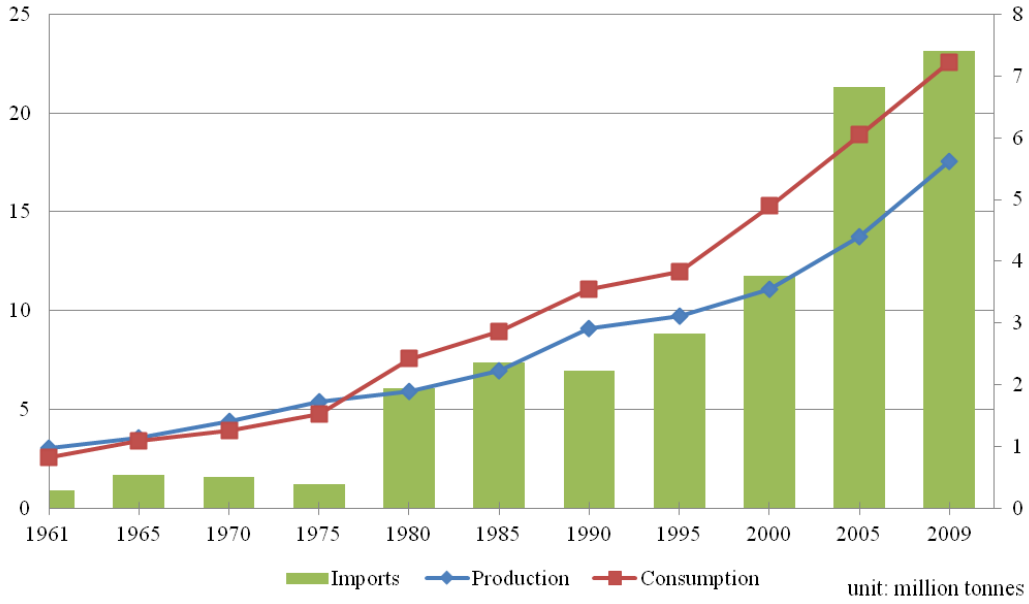


Figure 14 Rice production, consumption and import in SSA*

(Source: own graph based on FAO STAT)

*Chad, Congo, Côte d'Ivoire, Ethiopia, Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Liberia, Madagascar, Malawi, Mali, Mauritania, Mozambique, Niger, Nigeria, Rwanda, Senegal, Sierra Leone, Sudan (former), Togo, Uganda (data not available in Eritrea and Democratic Republic of the Congo/Zaire).

Since NERICA stagnation is sometimes attributed to cuisine culture (when people hear that NERICA is not adopted well in SSA, they sometimes draw a quick conclusion such as 'people in Africa traditionally do not eat rice as a staple food so they cannot adopt NERICA'), I would like to discuss about rice eating practice in Africa further. In the first place, many West and Central African countries traditionally eat rice as it was partially mentioned in the introduction section. Furthermore, not only in these countries, but also in East Africa where traditional staple foods are maize and cassava, the consumption of rice is increasing. Since 2000, rice has become a grain of third largest calorie intakes for people in SSA (Figure15) and this was mainly because rice is easy to cook compared to maize and other traditional grains, hence, rice is often consumed in urban area (Otaka, 2008).

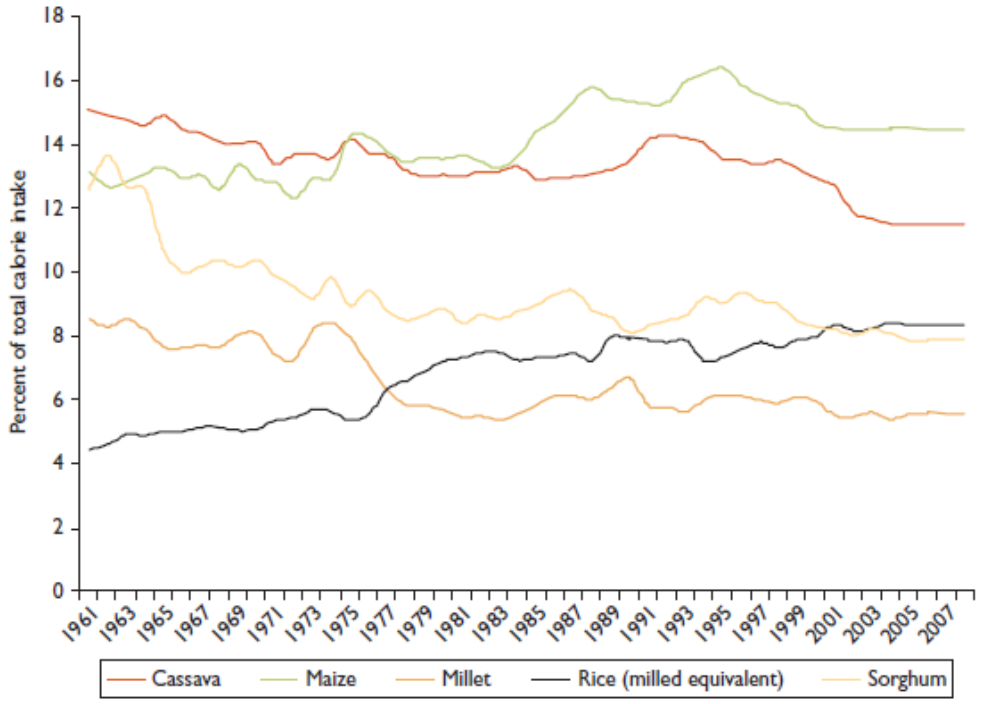


Figure 15 Sources of calories in African diet 1961-2007

(Source: Diagne *et al*, 2011)

As discussed in this second section, the surrounding social conditions of NERICA do not show any major differences from the conditions of the (pre)implementation phase of GR, in terms of 1) direct demand of food (hunger and poverty), 2) decreasing arable land per capita that is a precondition for large adoption of MVs, and 3) high demand for grains that could be explained by the supply and demand of a market system. Therefore, attribution of stagnated NERICA adoption to those domestic social conditions is invalidated. Moreover, as Hayami argued, even if the low development of social infrastructure is the sole and genuine cause for NERICA stagnation, in reality, there is no ultimate solution that would solve the low development of social infrastructure in a short term. Hence, further exploration for other realistic solutions is necessary and legitimate.

4 ANALYSIS ON INTERNATIONAL SOCIAL CONDITIONS

4.1 Introduction

> Organizations are usually products of their historical context. That context is shaped by major issues of substance, and critical events that are then dominating the political, economic and social debate. In 1945 these were: how to return the world to peace, and as important, how to manage the future so war does not return; how to prevent the deprivations of the Depression from reoccurring; how to organize the international economy so that parochial nationalism does not recreate the economic chaos of choking trade barriers, financial instability and inconvertible exchange rates of the 1930's; and how to assure all have access to sufficient food. Conceptual models of how to accomplish these objectives were driven by prevailing paradigms about: economic and agricultural development; how to accommodate Keynesian nationalistic economic models to the need for international interaction; the ensuring of the critical role of physical infrastructure; the need for technical assistance; and how to meet the essential need for international capital transfers. Paradigms need to be converted to processes and approaches-- the how of development. This required inventing new mechanisms of multilateral cooperation to replace previously unsuccessful attempts such as through the League of Nations, but also to learn from other international initiatives that had some success. (McCalla, 2007a)

International society has experienced dynamic shifts within a half century after World War II (WWII) in diverse ways. In the previous section, the similarities of social conditions at the domestic level were identified, and in this section, the social phenomena and trends between the time of the Green Revolution (GR: 1940s-1960s) and the present (1990s-) at the international level are testified. Since the domestic social conditions in Mexico, India, and Pakistan during GR and the present SSA are similar, this section focuses on the international

social conditions to indicate the differences. This is because my hypothesis is the implementation of MVs is influenced by the international society, hence, once international society experienced the shifts, the different social conditions caused by the shifts are reflected the implementation system and caused differences in them. The goal of this study is to indicate how the implementation system (such as strategic, operation, and financial management of projects and program) affects the modern varieties (MVs) adoption. Since the international phenomena and trends are interrelated to the implementation schemes (this is because development and implementation of MVs cannot be achieved without international cooperation), the differences at the international level are directly reflected to the differences of both implementation processes of semi-dwarf wheat and NERICA. Hence, this section not only discusses the international phenomena and trends, but also analyzes how those are related to the implementation process.

At least, there are concrete and visible differences in the implementation process of both semi-dwarf wheat and NERICA; a number of stakeholders, a command structure, and a budget system. In fact, as for the implementation of semi-dwarf wheat in Mexico, the major stakeholders were few: Rockefeller foundation (RF), Mexican government, national research center sponsored by the foundation. On the other hand, NERICA's implementation consists of diverse stakeholders; AfricaRice that is one of Consultative Group on International Agricultural Research (CGIAR)'s research centers and it hosts Africa Rice Initiative (ARI),

the Rice Research and Development Network for West and Central Africa (ROCARIZ), and other research centers and networks. In addition, those are financially supported by FAO, African Development Bank (ADB), Sasakawa Africa Association (SAA), ARI, and other international organizations (Guei *et al*., 2008). Furthermore, when it comes to the implementation project at national level, the numbers of stakeholder are emerged: mainly agricultural sector of the national government, national research center, and technical experts and evaluation members from donor side. For instance, in the one project from Uganda 2008-2011, main stakeholders are from National Agricultural Research Organization (NARO), Mational research Insutiture (NaCRRI), Zonal Agricultural Resarech and Development Institutes (ZARDI) and Japan Institutional Cooperation Agency (JICA) (JICA Summary Sheet, 2011). Moreover, this project is interrelated to other three projects (offered also by JICA) that are not about the implementation of NERICA (such as irrigated agricultural development project). In short, the mechanism of implementation system of NERICA became complex.

Moreover, in terms of the command structure, during the time of GR, the implementation system was a stereotype top-down approach. When semi-dwarf wheat was implemented in Mexico, RF was authorized as a founding sponsor and a decision maker, thus, not only local farmers' opinion, but even Mexican government's opinion was hardly reflected to the implementation phase or development of semi-dwarf wheat. On the other hand, implementation of NERICA aims to realize bottom-up approach. One representative example

is participatory varietal selection (PVS, or it sometimes called PVS Research/PVSR), "that favours farmers playing an active role in varietal selection, development and spread (Gridley, 2002)." AfricaRice which takes a role of research and development of MVs including NERICA uses this approach to spread MVs to the local farmers. This is a three-year program that:

> In the first year, breeders identify centralised fields near villages and plant a 'rice garden' trial of up to 60 upland varieties. The varieties range from traditional and popular O. sativas to NERICAs, African O. glaberrimas and local checks. Men and women farmers are invited to visit informally the plot as often as possible. […]Each farmer's varietal selection and the criteria for selection are recorded and later analyzed. In the second year, each farmer receives as many as six of the varieties he or she has selected in the first year to grow on his or her farm. Thus genetic diversity enters the communities. PVS observers, who may compromise breeders and/or technicians from NGOs and Extension Services, visit participating farmers' fields to record performance and farmer appreciation of the selected varieties. At the end of the year, farmers evaluate threshability and palatability to provide an overall view of the strengths and weaknesses of the selected varieties. For the third year, farmers are asked to pay for seeds of the varieties they select providing evidence of the value they place on them. Thus, in three years, PVSR allows the farmers to select varieties with specific adaptation and preferred plant type and grain quality characters. These, in turn, can be integrated into the breeding programmes to tailor varieties for farmers (Gridley, 2002).

Unlike the time of GR, scientists of NERICA consider the farmers' preferences more and they reflect the preferences to the development of new varieties.

4.2 Methodology

Hence, my hypothesis for this analysis is that those differences in the implementation system (that will be analyzed in detail in the section 5, analysis on implementation system), for instance, diversity of the stakeholders and command structures, attributed to the differences of international phenomena and trends. To testify the hypothesis, three academic philosophies are used; international relations, development economics, and agricultural research and development (Table 10). Hence, in this section focuses on the three factors that seem to cause the differences: 1) a transition of power balance in the international society, 2) failures of international aids, and 3) limited funding of international research centers.

Table 10 Hypothetical framework for international social conditions

	Green Revolution (1940s-1960s)	**Contemporary SSA (1990s-present)**
International Relations	polarity	multipolarity
Development Economics	Big push	Self-help effort
Agricultural R&D	Simple/unrestricted	Complicated/restricted

4.3 Results and Discussions

4.3.1 How did the security concepts and stakeholders diversify?

Since development and implementation of MVs require the interactions between developed countries (including international organizations mainly authorized by developed countries) and less developed countries (LDCs), international relations could not be ignored.

Moreover, there needs to be understood that the interaction, for instance, a decision making process at the international level, is often privileged by developed countries which are technologically and economically advanced. Therefore, this part determines how developed countries (donor countries) perceive the international relations during the time of GR and present. Before and after the Cold War, values and principles that each country has have been changed and what countries prioritize to secure and flourish their own has become diverse. To illustrate the relations of international society, scholars from security studies that have the academic background of international relations (IR) and political science are the experts. Security studies is from the academic field of theoretical studies of "the nature, causes, effects, and prevention of war (Baldwin, 1995)" and emerged in the US and some calls it 'American Social Science.' Thus, since security has always been the main consideration for IR, it experienced dramatic transitions after the Cold War (Peou, 2009).

When the concept of security is changed and diversified, tools to deliver the security are also changed and diversified. A reason that I believe security studies was an important tool to analyze the implementation scheme of the MVs is that MVs is one of development aids, in other word, diplomatic cables. The contents and goals of diplomatic cable are parallel to the political matters especially, security issues at international level and domestic level. "During the era of bipolar politics, security cooperation among industrial and LDCs used to be controlled exclusively by conventional security institutions. Since 1990, the dramatic changed

in the post-Cold War agenda have entailed the revisiting of OECD donors' role in face of urgent challenges of security and development resulting from the dissolution of the Soviet Union and the escalation of instabilities and conflicts in developing and transition countries (Ta Thi, 2005)." Therefore, revealing the perception of security which is a factor that affects each county's behavior and value explains consequential changes in the implementation system of MVs. The first semi-dwarf wheat was introduced right after the WWII and spread to Asia during the Vietnam war (1960-1975) (MVs was introduced in Mexico, 1946 and spread to India and Pakistan in 1965). Hence, GR occurred in the Cold War period when the third world escalations (proxy wars among LDCs) were ongoing. This situation of international society is called biplor system that there are two hegemon countries in the international society. Contrarily, first introduction of NERICA was 1994 that is post-Cold War periods and this time is categorized as multipolar system that contains several potential hegemon countries.

According to the scholars from security studies, the end of the Cold War changed the nature of international society and the perception toward the security at domestic level, so, actions towards international cooperation and development aid have also been changed. In the middle of 1990s, David Baldwin depicted the end of the Cold War as:

> Paraphrasing John F. Kennedy on the advent of nuclear weapons, one scholar sees the end of the cold war as changing "all the answers and all the questions." Another scholar, however, denies that there have been any "fundamental changed in the nature of international politics science World War II" and asserts that states will have to worry as

> much about military security as they did during the cold war. […] there is a need to reexamine the way we think about international relations and national security. For some this need stems from the changed circumstances of the post-cold war world; for others it grows out of the collective failure of scholars to anticipate either the timing or the nature of the end of the cold war. And there is [also] a need for a broader view of national security. For some this means including domestic problems on the national security agenda; for others it means treating nonmilitary external threats to national well-being as security issues (Baldwin, 1995).

The end of the Cold War meant the collapse of unipolarity that is a significant factor caused diversification of scholars, politicians and citizens' security perception whereas the perception was a common and unified during the Cold War. Security studies generally assume that what country prioritizes for its own national security is a relative value, and as Baldwin suggests, the collapse of biplolar system of international society diversified the concept of security.

Before the end of the Cold War, insecurity for the country was mainly a military issue. Especially the scholars who take a position of realist security studies, "regard unipolar or hegemonic system as more prone to international stability, peace, and security than multipolar ones (Peou, 2010)." Thus, during the Cold War which is defined as the time of bipolar system, security was pursued through the competitions between the US (and other democratic countries) and the Soviet Union (and other communist countries) by armed force. However, after the Cold War, democratic countries lost their visible cause of insecurity. As a result, a perception of insecurity for the country lost its unity, and due to the nature of relativeness in the concept of security, other issues such as transnational organized crime, economic, environment, population threat, migration, and pandemics, so called nontraditional security

issues were recognized (Peou, 2010). In addition, although bipolar system has been collapsed, the stabilized unipolar system has not been realized or military issues have not been solved. Some scholars define the present international society as mulitipolarity and suggest the possibility of potential hegemon countries.

For example, American political scientist John Mearsheimer who is a representative offensive realist of security studies argues "if the power structures that are now in place in Europe and Northeast Asia are benign, they are not sustainable for much longer. […] (In Europe), the region will probably move from its present bipolarity (with the United States and Russia as the poles) to unbalanced multipolarity, which will lead to more intense security competition among the European powers.[…] Northeast Asia will fall into unbalanced multipolarrity and the United States will move to contain the Chinese threat. Because China has such vast latent power potential (Mearsheimer, 2001)." Moreover, while Mearshimer warns the danger of rising new hegemon countries and consequential conflicts between those rising countries in Europe and Northeast Asia. Furthermore, Kwesi Aning from Kofi Annan International Peacekeeping Centre (KAIPTC) raises another issue which is about War on Terror (WOT). WOT is a declaration by the US government in 2001 and it is to declare the top priority to be a campaign to combat terrorism. Aning says that after the declaration of WOT, "[the United States'] allies has also had global war of the 21st century, bringing with it transcending consequences in international politics and world order. This situation has

affected the order of global priorities in many spheres and relegated several other wise important global issues to second place. One major impact has been on the discourse of international development (Aning, 2010).”

Therefore, the security concepts and principles that members of international society have became diverse compared to the time of GR. Hence, stakeholder countries of semi-dwarf wheat implementation in Mexico, India, and Pakistan, and adoption of NERICA in SSA have been motivated differently. When semi-dwarf wheat was implemented, the members of international society shared the concept of what is being secured against, whereas when NERICA was implemented in the post-Cold War period, they started to have diverse definition of insecurity and how to provide security. Consequently, as some scholars like Aning contends, the transformation of security concepts directly impacted behaviors of donor countries of international aid and the allocation of the aid. For instance, in terms of ODA, participating donor countries has become diverse. In 1960, the ODA donor was 17 countries: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Italy, Japan, Netherlands, New Zealand, Norway, Sweden, Switzerland, UK and the US. However, in 1990s, the numbers of countries that cooperate to ODA increased to 27 countries in total: Czech Republic, Greece, Iceland, Korea, Luxembourg, Poland, Portugal, Slovak Republic, Spain, and Ireland were newly joined (OECD Statistics). The investment of ODA is like holding stocks of a company, more you invest, more your opinion is reflected to the

international society. Thus, increasing numbers of donor implicates diverse opinions of 'stockholders' are found and reflected to the international society in terms of the development aids. In other words, form IR, the concepts of security have been diversified and a numbers of stakeholders has been increased.

4.3.2 How have theories of Development Economics shifted?

In the previous international relations part, actors who provide development aid including development of MVs were analyzed based on security studies aspect, and this part more focuses on the discourse of development aid itself. In terms of development aid, development economists are the experts to depict how development aid has been shifted from top-down approach to bottom-up approach, thus, this part follows theoretical transition of development economics. A famous development economist, Joseph Eugene Stieglitz depicts the transition of development aid and its failure:

> A central question in development economics is, how can we account for differences in the levels of income and the rates of growth between the developed and less developed economies? In the 1950s and 1960s, there was a standard answer to this question: the poor are just like the rich, except they are poorer-they have less human and nonhuman capital. There was an immediate prescription for this diagnosis: increase the resources of LDCs [Least Developed Countries], either by transferring capital to them (either direct aid or education) or by encouraging them to save more. Today [in 1989], these answers seem less convincing that they did two decades ago. If the problem were primarily a shortage of physical capital, the return to capital should be much higher in LDCs than in developed countries, and the natural avarice of capitalists would lead to a flow of capital from the more developed to the less developed economies. […] If the problem were primarily a shortage of human capital, then the educated in LDCs should

> receive a higher (absolute as well as relative) income than the educated in more developed economies. (Stieglitz, 1989)

How, then, development economics was perceived during GR? Since end of the WWII, studies about LDCs have been recognized more than before by west countries, and the nature of the studies has been shifted from understanding their own colonial states to proposing policies that solve chronic poverty in LDCs (Meier, 2004) which was the origin of development economics departing from classical Keynesian economics. During the time of GR (the end of 1940s to the early 1960s), three theories became popular: big push model by Rodan (1943), vicious circle of poverty by Nurkse (1953), and Singer-Prebisch thesis (1950 and 1959). Big push model is known for the other name of balanced-growth theory which indicates that the greater investment in many industries may convert the losses into profits. In other words, the industrialization of LDCs through large-scale investment in social infrastructure and basic industries solve the poverty trap of LDCs (Meier, 2004). Nrukse developed the balanced-growth theory further. Nurkse defines poverty in LDCs as 'vicious circle of poverty' which "implies a circular constellation of forces tending to act and react in such a way as to keep a country in the state of poverty (Nurkse, 1953)." Thus, in order to break the vicious circle of low income, low investment, low productivity, and low development, expand the investment, and enlarge the market through increasing entrepreneurship and export revenue. For developed countries, those theories justified the large investment and monetary aid to LDCs. In addition, Singer-Prebisch thesis which is

about as income rises, the demand for manufactured goods increases faster than the demand for primary products, accelerated large investments, import substitution industrializing policies and the commodity exchange became a tool for development (Meier, 2004). As it could be observed from those new rising theories, for LDCs, an ultimate goal of economical development and a path to achieve such goal were clearly defined by the donor countries and GR was spread over the world in such environment. In that sense, top-down approach was the only choice for the donor countries to provide development aid. In fact, the opinions of Mexican government were hardly reflected to the development of MVs in Mexico by the American researchers until the government took a radical action which was a forced repatriation of American RF members in 1957 (Bickel, 1974).

However, when NERICA was developed and implemented, development economics have gone through several transitions and necessitated a change in the development approach from top-down to bottom-up due to the continuous failures of development aids. First failure was revealed in 1970s, the big push model development aid and import substitution industrializing policies became obsolete, because LDCs did not grow as much as it was expected. Moreover, those stagnated growth was perceived as a cause of unequal distribution of wealth. Since the cause of poverty in LDCs was defined as a failure of the market, previous theories recommended governmental intervention and developed countries expected the trickledown effect (richer members of society will benefit poorer members by improving the

economy as a whole) in LDCs through development aids. Therefore, new theories were originated to antithesis of the previous theories, and the new studies recognized the diverse natures of LDCs and focused more on microeconomics such as individual production and income rather than former aggregate growth model such as studies about development strategies on tariff and agricultural subsidy (Meier, 2004). Those new trends on development economics gave positive impacts on the rising international organizations. In the 1970s, International Labour Organization (ILO), International Monetary Fund (IMF), and WB took drastic revision on development aid. That proceeded education, health, and employment through public sectors to secure basic human needs in LDCs (ILO, 1976 and Eldis, 2006). Such actions shed light on the poor people at micro level. The importance of self-help effort of LDCs was acknowledged, although a debate about 'how to promote self-help effort' was still remained. Furthermore, this was when scholars argued the negative impacts of traditional agricultural policy that public sectors were deserving large-scale farmers by undermining small-scale farmers (Meier, 2004). Along the criticism of prioritization of large-scale farmers, negative perceptions of GR were also arisen as a criminal of unequal distribution of wealth, environmental degradation, and intra-national conflicts in LDCs. "Germplasm improvement and associated biological research has been unpopular in the constituencies of some key donors because of negative perceptions of the Green Revolution – that it made the rich richer and the poor poorer and caused environmental damage (CGIAR, 2003)."As a result, MVs was

also counted as one of failures in the former development aids and became unpopular.

Third transition of development aid arose in the late 1980s. After the international debt crisis was taken place since 1982, donor countries promoted small government and privatization in LDCs. To manage the international debt crisis, Washington Consensus[11] that was a set of 10 policies, for instance, financial liberalization, trade liberalization, privatization, and deregulation was introduced in 1989, and international organizations such as IMF and WB followed it. Those organizations required recipient countries to privatize public sectors as a qualification of receiving assistances (Abe, 2013). Some scholars took this as second failure of development aid and new counter studies arose, and new studies were summarized mainly in the counter argument of privatizations and Washington Consensus.

> […] privatization is fundamentally unfair in both concept and implementation: it is seen as harming the poor, the disenfranchised, the workers, and even the middle class; throwing people out of good jobs and into poor ones or unemployment; raising prices for essential services; giving away national treasures—and all this to the benefit of the local elite, agile or corrupt politicians, and foreign corporations and investors. The complaint is that, even if privatization contributes to improved efficiency and financial performance (some question this as well), it has a negative effect on the distribution of wealth, income and political power. (Birdsell and Nellis, 2002)

In addition to those counter studies on privatization, some other scholars such as Joseph Eugene Stieglitz and Amartya Sen further developed micro aspects of development economics to "identify why markets do not work in the way hypothesized by neoclassical

[11]10 policies are: Fiscal discipline/ Public expenditure priorities/ Tax reform/ Financial liberalization/(management of)Exchange rates/ Trade liberalization/ Increasing foreign direct investment (FDI)/ Privatization/ Deregulation/ Secure intellectual property rights (IPR)/Reduced role for the state. (Source: WHO Trade, foreign policy, diplomacy and health. http://www.who.int/trade/glossary/story094/en/)

theory (Stieglitz, 1989),” and to recover market failures, rising development economists focus more on microeconomics and human being. Sen presented a famous concept of ‘capability’ to assess poverty. Sen explains, “capability is, thus, a set of vectors of functionings, reflecting the person’s freedom to lead one type of life or another. Just as the so-called ‘budget set’ in the commodity space represents a person’s freedom to buy commodity bundles, the ‘capability set’ in the functioning space reflects the person’s freedom to choose from possible livings (Sen, 1992).” As those new theories attracted attentions, new methodologies of development aid were extended: participatory development, BOP business, and micro finance (Abe, 2013). Hence, when NERICA was developed—during such transition when Washington Consensus’ failure strongly indicated and new micro-level development aid became popular, bottom-up approach was a major trend of development aids to realize self-help effort of LDCs.

In fact, majority of donor countries reviewed their development aids in 1990s, and that movement was later lead to Millennium Development Goals (MDGs) in 2000 to develop internationally shared development goals. In terms of NERICA for instance, Japan, one of the large donor countries revised basic policies of ODA from the concept of noblesse oblige to prioritize self-help effort of LDCs.

> In a publication “The philosophies of Economic Cooperation: Why Official Development Assistance?” issued in 1980, the Ministry stated that Japan's economic cooperation is guided by two motives: “humanitarian and moral considerations" and "the recognition of interdependence among nations.” […] It concluded that providing

> ODA is a cost for building an international environment to secure Japan's comprehensive security. […] Incorporating the philosophies and objectives of Japan's foreign aid which have evolved over the years, the Cabinet adopted on June 30, 1992, Japan's Official Development Assistance Charter (ODA Charter). As basic philosophies of Japan's ODA, the ODA Charter lists (1) humanitarian considerations, (2) recognition of interdependence among nations of the international community, (3) environmental consideration, and (4) support for self-help efforts of recipient countries (MOFA Japan, 1994).

In terms of development economics, the approach of development aids has experienced dynamic transitions from big-push model to self-help effort due to the historical failures of poverty eradication, and the transition has been reflected to the implementation of development aids from top-down to bottom-up approach.

4.3.3 How has Agricultural Research and Development (R&D) organized?

The role of agriculture in development and poverty alleviation, including that of agricultural research, has been reevaluated in recent years (World Bank, 2007). Research, development, and expansion of MVs was once a minor measure to eradicate potential food crisis in LDCs. Agricultural research and development of traditional agricultural products and technology transfer from developed countries were major measures of increasing agricultural productivity in LDCs. However, research, development, and expansion of MVs are now categorized as one of agricultural innovations. As such categorization was permeated, the studies on agricultural innovation has deepened and been characterized as taking place not only in university’s laboratory of developed countries, but in international research networks.

“Agricultural innovation typically arises through dynamic interaction among the multitude of actors involved. […] For innovation to occur, interactions among these diverse stakeholders need to be open and to draw upon the most appropriate available knowledge (World Bank, 2012).” Hence, back in the time of GR, research and development for agricultural innovation were much more primitive than it is now. “FAO’s initial and primary focus was on collecting, analyzing, interpreting and disseminating information, not generating it. […] In fact the dominant focus of agricultural development in the 1950’s and 1960’s was on extension, technology transfer and physical infrastructure. While there were a few agencies such as IICA (Inter-American Institute for Cooperation on Agriculture) and the RF pressing for agricultural research focused on food crops in tropical agriculture, most attention was focused teaching backward farmers to use technology developed in rich countries (McCalla, 2007b).” In short, in the early stage of GR, international society was not involved in development of MVs as much as it is for NERICA. Fortunately, international involvement of agricultural innovations prospered later and at the time of NERICA, numbers of stakeholders were too huge and complex to comprehend at once. In fact, CGIAR (that was created based on the research and development system of semi-dwarf wheat in Mexico, and NERICA was developed under this network) acknowledged that “over the years our membership became more diverse. More countries in the developing world joined as well as other development agencies and foundations (Table 11).” Contrarily, functions and discretions of the international research

Table 11 CGIAR members chronology

Joined	Members
2005	Turkey
2003	Gulf Cooperation Council
2002	Israel, Malaysia, Morocco, Syngenta Foundation
1998	Uganda
1997	Pakistan, Republic of South Africa, Portugal, Peru, Thailand
1996	Côte d'Ivoire
1995	Bangladesh, Egypt, Iran, Kenya, Romania, Syria
1994	Russian Federation, Colombia
1993	Indonesia
1991	Luxembourg, Korea
1985	Austria
1984	Brazil, China, Finland
1981	India, Spain
1980	Mexico, Philippines, OPEC Fund for International Development
1979	Ireland, International Fund for Agricultural Development
1978	African Development Bank
1977	Arab Fund for Economic and Social Development, Commission of the European Communities
1976	New Zealand
1975	Italy, Nigeria, Saudi Arabia
1974	United Nations Environment Programme
1972	Australia, Japan
1971	Belgium, Canada, Denmark, France, Germany, Netherlands, Norway, Sweden, Switzerland, United Kingdom, United States of America, Asian Development Bank, Food and Agriculture Organization of the United Nations, Inter-American Development Bank, International Development Research Center, United Nations Development Programme, World Bank, Ford Foundation, W.K. Kellogg Foundation, Rockefeller Foundation

(Source: CGIAR[12])

network have been constrained and intervened as numbers of stakeholder increased. In sum, this part discusses that the transition of international agricultural research and development

12 CGIAR official homepage "Members Chronology": http://www.cgiar.org/who-we-are/history-of-cgiar/members-chronology/

over the time and its effects on structuring each implementation system in India, Mexico, and Pakistan and SSA.

Historically, international agricultural research and development have been aimed to produce sufficient foods for rapidly increasing population in the 20th century. “Clearly the application of science to agriculture had research roots dating back at least to Von Liebig in the mid 19th century, but it was increasing investments in applied research in developed countries in the first half of the 20th century that led to the genetic and chemical revolution that drove agriculture in the second half of the 20th century. However, in 1945, when FAO was established, the dominant concern was food and nutrition problems in Europe which were seen as a food production problem caused by lack of land and farmer’s using primitive methods (McCalla, 2007b).” Thus, development of MVs was not perceived as a major solution to react the potential food crisis until the high adoption was achieved in Mexico, India, and Pakistan. Since the comprehensions of agricultural innovations was low at the international level, in the early stage of the MVs development (during the time which I define as GR), any international organizations were not major actors for the agricultural research and development. Contrarily, RF, Ford Foundation (FF), and the U.S. government were fascinated by increasing productivity in LDCs through the development of innovative agricultural technologies.

In the 1960s, once international research centers (IRRI, CIMMYT, etc) were established by the collaboration of RF and FF in LDCs to develop and expand semi-dwarf wheat, rice and other grains, it "exceeded the Foundation capacity to finance them. […] Heads of three UN Agencies – the World Bank(WB), UNDP, and FAO, the heads of the U.S., Canadian, Swedish and British Aid Agencies plus senior leadership from the two Foundations, the Asian Development Bank (ABD), the Inter-American Development Bank (IDB) and the Japanese Aid Agency […] focused on the need for support for international agricultural research […] as well to stimulate agricultural development. In particular, there was support for developing sustained financing for the four existing centers plus possibly five or six more that were either at the gates available for admission or whose development was seen as necessary (McCalla, 2007b)."

Since then, MVs research, development, and expansion have been financially managed under the international cooperation (Table 11). In 1971, the international cooperation and existing research centers formed a new international funding mechanism called *CGIAR* and it "was a loose consortium of donors –international financial institutions led by the World Bank, bilateral donors, foundations and multinational entities such as the EU who together supported an expanded system of independent institutes (McCalla, 2007a)." After the formation of CGIAR, numbers of research center under CGIAR has increased rapidly and West Africa Rice Development Association (WARDA; changed its name AfricaRice in 2009)

Table 12 CGIAR centers chronology

Center	Founded	Joined CGIAR	Merged	Headquarters
Center for International Forestry Research (CIFOR)	1993	1993		Bogor, Indonesia
WorldFish Center previously International Center for Living Aquatic resources (ICLARM)	1977	1992		Manila, Philippines
International Network for the Improvement of Banana and Plantain (INIBAP)	1984	1992	1994 with IPGRI	Montpellier, France
World Agroforestry Centre (previously ICRAF)	1977	1991		Nairobi, Kenya
International Water Management Institute (IWMI)	1984	1991		Colombo, Sri Lanka
International Service for National Agricultural Research (ISNAR)	1980	1980	2004 into IFPRI	The Hague, Netherlands
International Food Policy Research Institute (IFPRI)	1974	1979		Washington, DC, United States of America
Africa Rice Center previously the West Africa Rice Development Association (WARDA/AfricaRice)	1970	1975		Bouake, Cote d'Ivoire
International Center for Agricultural Research in the Dry Areas (ICARDA)	1975	1975		Aleppo, Syria
International Livestock Center for Africa (ILCA)	1974	1974	1994 with ILRAD and became ILRI	Addis Ababa, Ethiopia
Bioversity International previously International Plant Genetic Resources Research Institute (IPGRI)	1974	1974		Rome, Italy
Centro Internacional de la Papa (CIP)	1970	1973		Lima, Peru
International Laboratory for Research on Animal Diseases (ILRAD)	1973	1973	1994 with ILCA and became ILRI	Nairobi, Kenya

Center	Founded	Joined CGIAR	Merged	Headquarters
International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)	1972	1972		Hyderabad, India
International Rice Research Institute (IRRI)	1960	1971		Los Baños, Phillippines
Centro Internacional de Mejoramiento de Maiz y Trigo (CIMMYT)	1966	1971		Mexico City, Mexico
Centro Internacional de Agricultura Tropical (CIAT)	1967	1971		Cali, Colombia
International Institute of Tropical Agriculture (IITA)	1967	1971		Ibadan, Nigeria

(Source: CGIAR[13])

also joined CGIAR in 1975 (Table 12). AfricaRice is a research center where NERICA was researched and developed, and it "was created in 1971 by 11 African countries with the assistance of the United Nations Development Programme (UNDP), the Food and Agriculture Organization of the United Nations (FAO), and the Economic Commission for Africa (ECA). […] Recognizing the strategic importance of rice for Africa and the effective geographic expansion of the Center (AfricaRice[14])." Under status quo, 25 countries in total joined AfricaRice : Benin, Burkina Faso, Cameroon, Central African Republic, Chad, Côte d'Ivoire, Democratic Republic of Congo, Egypt, Gabon, the Gambia, Ghana, Guinea, Guinea Bissau, Liberia, Madagascar, Mali, Mauritania, Niger, Nigeria, Republic of Congo, Rwanda, Senegal, Sierra Leone, Togo and Uganda (AfricaRice Member States). In addition, all those countries shown above, except Egypt and Gabon adopted NERICA by 2006 (Gridley *et al*, 2002 and

13 CGIAR official homepage "Centers Chlonology": http://www.cgiar.org/who-we-are/history-of-cgiar/centers-chronology/
14 AfricaRice official homepage: http://www.warda.cgiar.org/warda/aboutus.asp

Diagne *et al*, 2011). AfricaRice consists of not only West, Central, East and North African countries, but also large numbers of restricted and unrestricted donors (29 international agencies, international research centers, donor countries, and universities in 2011, refer to Appendix E).

In fact, CGIAR as a whole, there are significant changes in the funding and the expected roles and behaviors as an international research network in recent years. According to the CGIAR report in 2003, "the CGIAR's expenditures on productivity-enhancing agricultural research—a global or regional public good ideally suited to a publicly funded global network—declined by 6.5 percent annually in real terms between 1992 and 2001, and expenditures on improving policies and on protecting the environment increased by 3.1 percent in real terms annually. Overall CGIAR funding declined by 1.8 percent annually during this same time period. Meanwhile, the share of restricted funding increased from 36 percent to 57 percent, with the degree of restriction accelerating since 1998 (World Bank, 2003)." From the agricultural research and development aspects, a shift in the allocation of financial contribution was caused by the stakeholders in a position of power (i.e. key donors and international bank) and in the field of the agricultural research and development, the causes of such shift are understood as international financial crisis and negative perceptions of GR.

Moreover, there is another strong voice for the politics is also one major factor to constrains the agricultural research and development. “Aside from budgetary constraints, many public research organizations face serious institutional constraints that inhibit their effectiveness, constrain their ability to attract funds, and ultimately prevent them from functioning as a major contributor to the innovation system. The main constraints associated with […] strong path-dependency in institutional and policy change, such as the lack of consensus on a strategic vision, ineffective leadership and management, a continued emphasis on building centralized national agricultural research structures rather than on creating partnerships, the loss of highly qualified scientific staff, and weak links with and accountability to other actors involvement innovation process. (World Bank, 2012)” This is a result of conflict between international research centers and LDCs or in other words, it is inferred that lack of ability of international agencies to flexibly respond the demand from LDCs due to the political constrains by the donors who support the international agencies. In other words, international agricultural research and development, such as CGIAR is now facing a dilemma; to promote agricultural innovation and to develop the research framework in the diverse academic field, the research and development need funding, however, to raise the fund, a numbers of donors also increases which means, the research and development are more constrained by the donors.

To conclude this section, “organizations are usually products of their historical context”, as McCalla notes, the contemporary international society has been structured by the numerous historical events including a multitude of failures. Such paradigm shifts have affected the behaviors of donor countries and international agencies that lead the development and adoption of MVs. All three aspects shown in this section are not independent or individual causes that affect the emergence of differences in both semi-dwarf wheat and NERICA implementation, but they are interrelated each other. In terms of development aids as a whole, the collapse of bipolar system explains the diversification of donor countries’ perceptions toward the international society, and along with the diversified international recognitions, the conceptual expansion of development economics established the new landmarks for the donors’ behaviors. Such tendency explains why NERICA takes bottom-up approach while semi-dwarf wheat took top-down approach of the implementation. Moreover, agricultural research and development which directly links to the implementation of semi-dwarf wheat and NERICA are constrained by the multiple and diversified donors that are greatly influenced by the international paradigm shifts.

In short, NERICA implementation system is more diverse and complex than semi-dwarf wheat, and such differences are caused by the different academic discourses and social conditions at the international level. Hence, the system of MVs adoption is greatly influenced by the donors and this section revealed the necessity of further research on how the

donor should behave to make a difference in the MVs adoption, but not what LDCs should *have* for their development.

5 ANALYSIS ON IMPLEMENTATION SYSTEMS

5.1 Introduction

Again, the objective of this research is to indicate the cause(s) of NERICA stagnation through contextualization of the differences in the implementation systems between the semi-dwarf wheat and NERICA by assuming that the semi-dwarf wheat was a representative of successful cases in terms of modern varieties (MVs) adoption. The second section of this study explained social conditions at the domestic level is not validated as a major cause of the NERICA stagnation because significant differences could not be found in the domestic social conditions of the countries that adopted semi-dwarf wheat and NERICA. On the other hand, significant differences are found in the implementation systems of semi-dwarf wheat and NERICA, the third section, therefore, focused on the differences in the international society between the time when semi-dwarf wheat was adopted and the time when NERICA was adopted. The background analysis, then, identified that the differences at the international level seemed to directly affect the implementation system of MVs, and suggested the significances of the modifying implementation systems in order to improve the adoption of MVs (may include NERICA). Hence, this section verbalizes and contextualizes the *differences* to facilitate emerging the solutions to NERICA stagnation and further exploration

for efficiency of MVs adoption based on the observation discussed by organization theory (Burns & Stalker, 1961). Another reason for contextualization of the *differences* based on organization theory is that, unlike the business and market, implementation system of modern varieties is difficult to measure by the numerical statistics such as products and sales, thus, for this study, descriptions about important stakeholders are extracted to illustrate each implementation system.

The organization theory indicates two different forms of organization: one is called *mechanistic* which is a form of bureaucratic organization with hierarchy, and the other is *organic*, a non-bureaucratic and horizontal organization. As it was explained by the international social conditions, the organization structures shown in organization charts are: mechanistic and bureaucratic for semi-dwarf wheat during GR, and organic and horizontal for NERICA. However, when it is focused more on roles and behaviors of each stakeholder (i.e. donors, recipients, managers, researchers, and public officers), NERICA demonstrates more mechanistic tendencies while semi-dwarf wheat demonstrates the organic forms.

The implementation of semi-dwarf wheat in Mexico shown in the organization chart is characterized as a mechanistic form (Figure 16). A series of semi-dwarf wheat development was originated from Mexican Agricultural Project (MAP), and MAP was the Rockefeller Foundation (RF)'s first intensive agricultural endeavor. In the late 1930s, president of RF and US vice president held a meeting about food security in Mexico and around the same time,

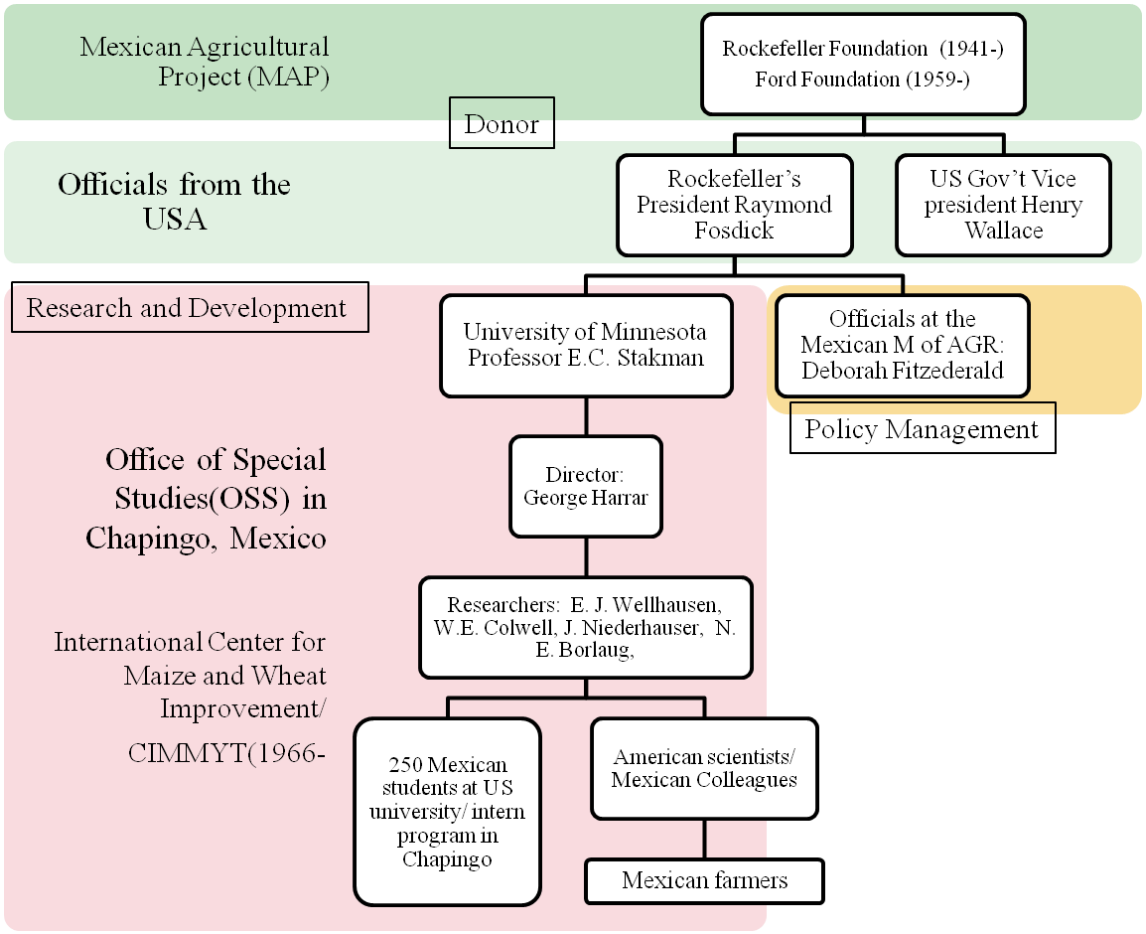


Figure 16 Organization chart of Mexican Agricultural Project (MAP)
(Source: Author's compilation based on Hesser, 2009., Kohler, 2009., and Rockefeller Foundation Archive Center)

the ministry of agriculture Mexico officially requested the US to support increasing the domestic food production. After project was designed, the president of RF appointed several researchers and scientists, led by Stakman, professor from University of Minnesota for the preliminary research. In 1941 Mexico had no academics with advanced degrees in agriculture and insufficient indigenous expertise to establish extension programs. Thus, in 1943, the RF signed a formal agreement with the Mexican government, which established a new department, the Office of Special Studies (OSS) to coordinate the program (Rockefeller

Foundation Archive Center[15], NA). OSS was managed by Harrar, as a director who was appointed by Stakman, under the cooperation of RF. Harrar appointed other researchers who were needed to develop MVs, including Borlaug, founder of semi-dwarf wheat. MAP utilized its experimentation stations to educate generations of indigenous Mexican agronomists. RF scientists brought to Mexico habits learned in U.S. land grant colleges, where fieldwork and academic research were integrated. In MAP's first twenty years, over 550 graduates of Mexican agricultural colleges served as apprentices and interns in the OSS. (Rockefeller Foundation Archive Center[15], NA; Hesser, 2009). Not only the relationship between donors (the U.S. government and RF) and recipients (Mexican government, farmers) but also between researchers, the organization chart demonstrates typical top-down approach and they are ranked hierarchically. Moreover, similar hierarchy could be found in the cases of India and Pakistan as well.

In case of India, there were two programs established by the Indian government that were related to the adoption of semi-dwarf wheat: National Demonstration Programme (1964) and High Yielding Varieties Programme (HYVP in 1966). The former one "introduce[d] farmers to the new opportunities opened up by semi-dwarf varieties (Pursuit and Promotion of Science, NA), and the latter one was "to stimulate food production including land reforms, irrigation, fertilizer production(Pursuit and Promotion of Science, NA)." Since 1950s, Indian

[15] All cited from Rockefeller Foundation Archive Center: http://rockefeller100.org/ (Retrieved on January 30, 2014)

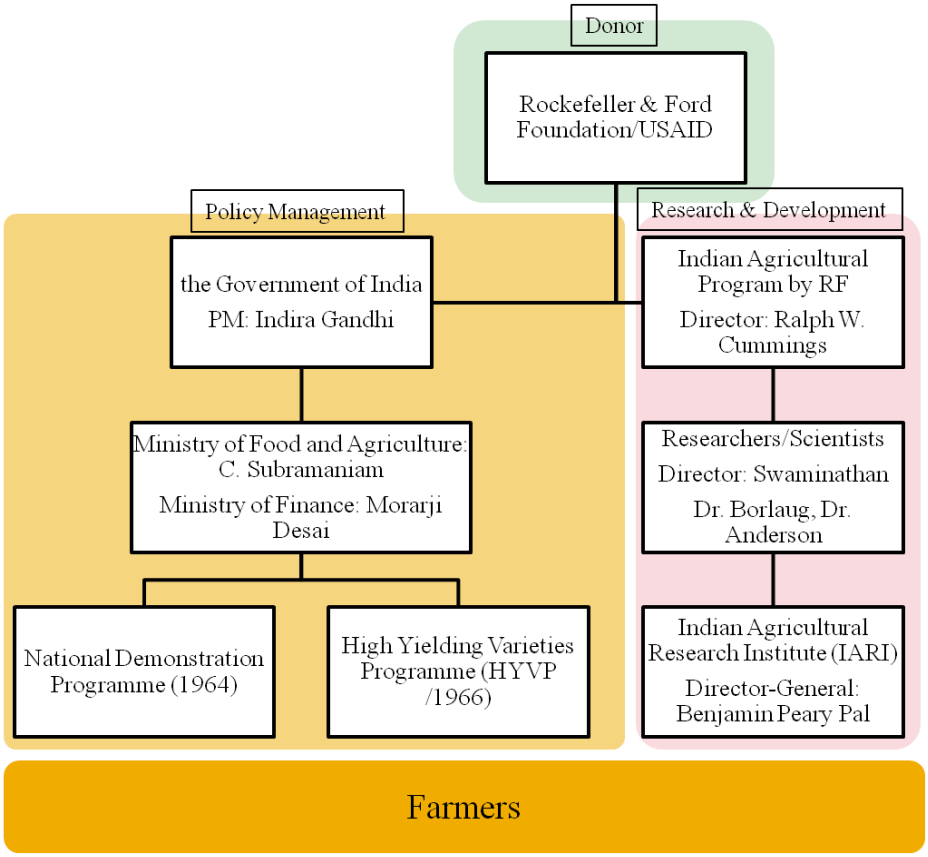


Figure 17 Organization chart of implementation in India

(Source: Author's compilation based on Hesser, 2009; Swaminathan, 1970; Pursuit and Promotion of Science, NA; Rockefeller Foundation Archive Center)

government initiated a research for developing non-lodging and fertilizer under Indian Agricultural Research Institute (IARI) to achieve self-sufficient in production in India. However, those trials did not succeed or RF could not be involved until 1964 when India decided to import the Mexican semi-dwarf wheat and accept researchers and scientists, Swaminathan, Borlaug, Anderson from RF. "To work effectively in India, the RF needed to adjust its usual approaches. The Foundation liked to work with established institutions in a country [as RF did in Mexico], trusting to their long experience and resources to help programs succeed. But, the Indian government preferred to emphasize equality and strengthen

weaker institutions. Government officials also wanted more direct oversight of RF allocations than the Foundation normally allowed. It took several years for the RF and the Indian government to establish mutually acceptable terms of agreement (Rockefeller Foundation Archive Center[15]).” Once semi-dwarf wheat increased domestic wheat products, National Demonstration Programme and High Yielding Varieties Programme were regulated on the basis of planting more semi-dwarf varieties with monitoring by RF and American scientists (Figure 17). Pakistan followed similar path to India.

> [In Pakistan,] population growth was outstripping food supply. Pakistan was relying increasingly on food aid under the US Food for Peace program, Pakistan’s citizens appreciated the donations, but they needed a permanent solution to their food problem. […] Dr. Ignacio Narvaez, who had been Borlaug’s deputy in Mexico, was now Ford Foundation advisor on wheat production in Pakistan. With [Dr. Ignacio Narvaez] as coach, with Curry Brookshier’s extenstion adcisors on the front lines, and with a Ford Foudation-wmployed Norwegian economist—Dr. Oddvar Aresvik, consultant to Mnister Khuda Bakhsh Bucha—sitting in an office adjacent to the minister’s office, Pakistan launched a national wheat production campaign in the fall of 1966. The campaingn was vbased on seed of the Mexican varieties that was harvested in Pakistan in April 1966, buttressed with Staley Pitts’ 5 tons of MexiPak. The 1967 harvest from fields planted to the MexiPak seed was excellent (Hesser, 2009).

In sum, when Mexico, India, and Pakistan adopted semi-dwarf wheat, they had to compromise and sometimes give up their sovereignty, especially research and development field. As a result, the relationship between recipients and donor became top-down and hierarchical.

Contrarily, in case of NERICA, the organization chart demonstrates different tendency from semi-dwarf wheat. Significant differences are horizontal relations and numbers of stakeholders, and the boundaries of the stakeholder groups are depicted either partnerships, networks, or collaborations (Figure 18). According to the NERICA compendium by AfricaRice, "The Africa Rice Center modus operendi is partnership at all level. [AfricaRice] is recognized as a partnership center with privileged relations with its constituency of [national agricultural research systems](NARS) (Guei *et al*, 2008)." For instance, the relationship with local farmers and research firms is horizontal under name of collaborative projects such as Participatory Variety Selection (PVS), Community-based Seed Production Systems (CBSS), and Participatory Learning and Action Research (PLAR). Its partnership and collaborative approach has been awarded by UN for South-South Triangular Partnership for its pioneering efforts in brokering North-South partnerships (Guei *et al*, 2008). Moreover, for the donors of research and development of NERICA, there are diverse international agencies and developed countries;

> For upstream research and development, the Interspecific Hybridization Project (IHP) model – a triangular South-South partnership – was developed to bring together the pool of expertise from advanced research institutes with that of national programs. […] It was supported by Japan, the United Nations Development Programme (UNDP), and the Rockefeller and Gatsby Foundations. The research on NERICA varieties has also been sponsored right from the beginning by the CGIAR. Research and development partners in the IHP include the International Rice Research Institute (IRRI); Centro Internacional de Agricultura Tropical (CIAT); Japan International Cooperation Agency (JICA); Japan International Research Center for Agricultural Sciences (JIRCAS); Institut de recherche pour le développement (IRD); Cornell, Tokyo and Yunnan Universities; and the national programs of African countries (Guei *et al*, 2008).

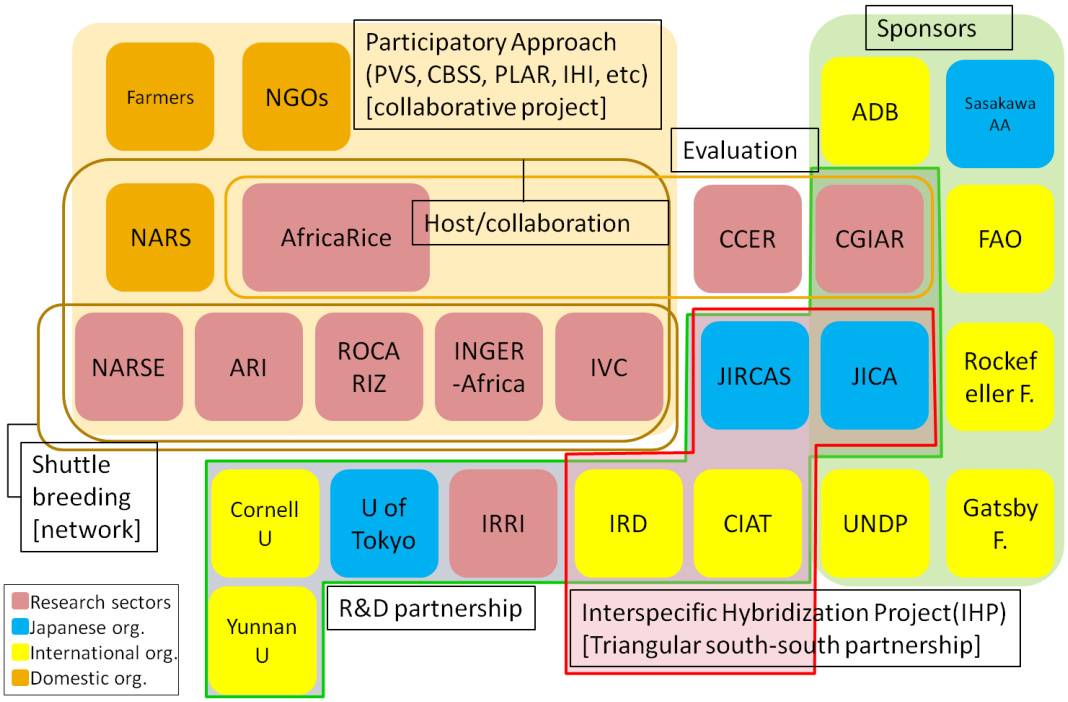


Figure 18 Organization chart of research and development of NERICA

(Source: Author's compilation based on Guei, 2008 and Mohapatra, 2007)

As for the shuttle breeding network which is one research and development procedure, there are five representative agencies/networks; ARI, INGER-Africa (The African wing of the International Network for Genetic Evaluation of Rice), IVC (Inland Valley Consortium), NARSE (National Agricultural Research and Extension System), and ROCARIZ (Réseau ouest et centre africain du riz/ West and Central Africa Rice research Network), and they are in charge of different varieties of NERICA in the different fields of research and development (Guei *et al*, 2008). Hence, the implementation system of NERICA realizes the bottom-up and organic form in terms of structure of the organization.

To conclude, the structures of implementation system shown in organization chart demonstrate mechanistic for semi-dwarf wheat and organic for NERICA. However, the

organization theory explains that organic forms perform better at unstable conditions such as engineering industry where continuous research and development conducted. Why then, did NERICA show the stagnation in the adoption whereas semi-dwarf wheat was adopted successfully? Is this case the first exception for the organization theory cannot explain? Before drawing a quick conclusion, I would like to observe both organization theory and the implementation system in detail in the following parts.

5.2 Methodology: Organization Theory

5.2.1 Theoretical rationale

Organization theory is not a classical major theory in either sociology or business administration field to analyze a structure of organization, though its name could be found in the introductory study on organization. Why, then this study uses the organization theory to analyze the implementation system? One significant reason is that as previous section discussed, the implementation system of semi-dwarf wheat demonstrates top-down and bureaucratic tendency, and the NERICA implementation has the bottom-up and non-bureaucratic tendency which is a result of several historical transitions. Thus, to conduct a comparative study, it is inferred that a theory with dualism analysis, in particular, a theory that explains both top-down/bureaucratic and bottom-up/non-bureaucratic organizations is applicable for this study.

This leads to the field of study on organization based on bureaucracy in the industrial research and development, in other words, innovation. The study is originated from the sociology of bureaucracy by Max Weber (1921) (Hasegawa *et al*, 2007). Max Weber identified six key elements of the ideal bureaucracy: specialization, hierarchy of office, rules and regulation, technical competence, impersonality and formal written communications (Macionis, 2008), and Weber noted that bureaucratic organization is rational and performs a task the most efficiently. Weber's bureaucracy reproduced numerous debates, and one of the debate led to the recognition of a variety of organizational forms and managerial structure. In The Management of Innovation (1961), Burns and Stalker distinguished between bureaucratic systems, which is named 'mechanistic' and non-bureaucratic which is 'organic' (Abercrombie *et al*, 1984). This organization theory is a significant turning point in the history of study on organization, and also that is another reason for this study to use the analysis of organization theory, because the organization theory plays an important role in sociology and business administration field, not for its analysis on the organizational forms and managerial structure, but for its suggestion of contingency approach (Hasegawa *et al*, 2007; Sakakibara, 2002). As it was mentioned, the organization theory indicates mechanistic and organic forms, in addition to that, this theory suggests that mechanistic forms are suitable for stable conditions such as uncompetitive markets and unchanging technology, whereas, organic forms are better for changing conditions (Abercrombie *et al*, 1984). This analytical finding is "recognized as the

fundamental study of contingency theory, the view that mechanistic and organic systems rationally and deterministically adapted to an environment made up of contingencies (Boje, 1999).” In the result, after the organization theory, the study on organization has headed to the two different paths in the theoretical transitions: one is the study on institutional approach to organizations based on contingency approach, known as institutional theory assumes that organizations are significantly affected by their social environment (Abercrombie *et al*, 1984). The other is seeking for efficient innovation management based on scientific management in the business administration field (Sakakibara, 2002). Therefore, in terms of study on structure of organization in the overlapped fields of technological development and bureaucracy, the organization theory is one major approach since the purpose of study on organization shifted to efficiency of business marketing and innovation, and strategy for survival of the organization by analyzing surrounding environmental factors that are not applicable to the comparative study on the MVs implementation system.

5.2.2 Modification of theory

In order to identify the comprehensible differences, this comparative study focuses on budget allocations, manifestoes and mission statements, and behaviors and communications of stakeholders for the implementation system of GR and NERICA. This is because under the framework of the organization theory, those three factors are the representative features. For

the disclaimer of this analysis, I acknowledge that this document review has a limitation on the obtained and analyzed information, and there is a possible unintended distortion during the process of the analysis. However, more importantly, this research aims to new possible solutions for the improvement of MVs adoption through the suggestions of the problems from the donor's side which is undermined in the present. Thus, if any field researchers and other workers on-site disagree with this analysis and establish a new counter argument, it is appreciated in the sense that the activated discussion for the implementation of MVs among donors will help the development of how to implement development aids for the better results. Moreover, in terms of a fact that the analysis has been made based on the officially disclosed information, the conditions between the cases from GR and NERICA are the same to maintain fairness.

Another important note is that the origin of this theory is inductive based on the case studies from business sector in UK; all case studies were indicated either mechanistic or organic. On the other hand, in the case of semi-dwarf wheat and NERICA, the theory needed some modification to properly indicate the implementation of both varieties, because this study uses the organization theory as one criteria to indicate the different features of MVs implementation. Thus, the modification of theory is discussed in the following, before moving to the analysis on the implementation of each variety.

The organization theory indicates 11 features for each mechanistic and organic forms of organization. Burns and Stalker identified the mechanistic and organic form as follow:

MECHANISTIC FORM

(*a*) the specialized differentiation of functional tasks into which the problems and tasks facing the concern as a whole are broken down;

(*b*) the abstract nature of each individual task, which is pursued with techniques and purposes more or less distinct from those of the concern as a whole; i.e., the functionaries tend to pursue the technical improvement of means, rather than the accomplishment of the ends of the concern;

(*c*) the reconciliation, for each level in the hierarchy, of these distinct performances by the immediate superiors, who are also, in turn, responsible for seeing that each is relevant in his own special part of the task;

(*d*) the precise definition of rights and obligations and technical methods attached to each functional role;

(*e*) the translation of rights and obligations and methods into the responsibilities of a functional position;

(*f*) hierarchic structure of control, authority, and communication;

(*g*) a reinforcement of the hierarchic structure by the location of knowledge of actualities exclusively at the top of the hierarchy, where the final reconciliation of distinct tasks and assessment of relevance is made.

(*h*) a tendency for interaction between members of the concern to be vertical, i.e., between superior and subordinate;

(*i*) a tendency for operations and working behavior to be governed by the instructions and decisions issued by superiors;

(*j*) insistence on loyalty to the concern and obedience to superiors as a condition of membership;

(*k*) a greater importance and prestige attaching to internal (local) than to general (cosmopolitan) knowledge, experience, and skill.

ORGANIC FORM

(*a*) the contributive nature of special knowledge and experience to the common task of the concern;

(*b*) the ‘realistic’ nature of the individual task, which is seen as set by the total situation of the concern;

(*c*) the adjustment and continual re-definition of individual tasks through interaction

with others;

(*d*) the shedding of 'responsibility' as a limited field of rights, obligations, and methods. (Problems may not be posted upwards, downwards, or sideways as being someone else's responsibility);

(*e*) the spread of commitment to the concern beyond any technical definition;

(*f*) a network structure of control, authority, and communication. The sanctions which apply to the individual's conduct in his working role derive more from presumed community of interest with the rest of the working organization in the survival and growth of the firm, and less from a contractual relationship between himself and a non-personal corporation, represented for him by an immediate superior;

(*g*) omniscience no longer imputed to the head of the concern; knowledge about the technical or commercial nature of the here and now task may be located anywhere in the network; this location becoming the ad hoc center of control authority and communication;

(*h*) a lateral rather than a vertical direction of communication through the organization, communication between people of different rank, also, resembling consultation rather than command;

(*i*) a content of communication which consists of information and advice rather than instructions and decisions;

(*j*) commitment to the concern's tasks and to the 'technological ethos' of material progress and expansion is more highly valued than loyalty and obedience;

(*k*) importance and prestige attach to affiliations and expertise valid in the industrial and technical and commercial milieux external to the firm. (Burns and Stalker, 1961)

Several important corollaries are, in their analysis, the organic systems are not hierarchic in the same sense as are mechanistic, though they remain stratified. The lead is taken by whoever shows himself most informed and capable under consensus, but not by seniors which is found in the mechanistic systems. Moreover, the two forms of system represent a polarity, not a dichotomy; there are intermediate stages between the extremities empirically observed (Burns and Stalker, 1961). Those corollaries allow this study to reach the analysis that mixed features of mechanistic and organic are found in each implementation system.

Although Burns and Stalker capture the features of mechanistic and organic forms in detail, the features are not straightforwardly applicable to the analysis of the implementation system, since those features are extracted results based on the case studies and the observations. Thus, I would like to extract key words and adjectives from the summarized version of the organization theory by Abercrombie, Crossman, and Sakakibara in order to apply them to this comparative analysis.

Abercrombie (1984) summarizes mechanistic forms as bureaucratic system (i.e. high degree of specialization, clearly defined division of labor, hierarchical structure of authority, formal body of rules to govern the organization, administration based on written documents, promotion on the basis of seniority or merit etc), and organic forms which maximize personal discretion, decentralize decision-making and minimize rule-bounded behavior. Next, Crossman notes that mechanistic features as high specialization, rigid departmentalization, clear chain of command, narrow spans of control, centralization, high formation, whereas organic features as cross-functional teams, cross-hierarchical teams, free flow of information, wide sans of control, decentralization, and low formalization (Crossman, N.A.). At last, Sakakibara (2002) emphasizes the five features for each form: as for mechanistic feature, 1) specialization of tasks, 2) rigid restriction on tasks, commissions, and rules and regulations, 3) centralized communication, 4) vertical transactions, and 5) fidelity for the organization, and as for organic features, 1) low specialization, 2) elastic and solution-oriented tasks, 3)

decentralized communication, 4) prioritization of horizontal transactions, and 5) joint-decision making with consensus. Those summaries specify the representative features of mechanistic and organic forms.

5.3 Results and Discussions

5.3.1 Budget allocations

Based on the organization theory and key words extracted in the previous part, this part focuses on the behaviors of stakeholders and milieux that affect the behaviors rather than the structures of the organization.

As a number of stakeholders increased, financial aspect became one key factor that affected the management of projects and programs in LDCs. Increasing stakeholders means the discretion of each stakeholder such as workers, managers, and researchers at local research centers is constrained more by the rules and regulations. Such tendency is highlighted in terms of the use of grant, because each donor has an obligation to state its expense is efficient and has positive impact as a development aid. During GR in a case of Mexico, funding, and development and research firm were from the same body, hence, objectives and management were easily shared by the stakeholders.

> With an initial outlay of $ 20,000 for a survey in 1943, followed in 1944, by $ 192,800 for construction costs and equipment, the Rockefeller Foundation embarked, with the Mexican Ministry of Agriculture, upon the Mexican Agricultural Project. […] By the

> time the Green Revolution really took off, […] the U.S. government provided funds. Over $1 million was allocated between 1966 and 1968, for example. (Kohler, 2009)

> Each of the collaborating agencies has contributed heavily to operating costs of the program: a total of $ 1,317,155 has been furnished to date by The Rockefeller Foundation and nearly a million pesos by the Mexican government. On these investments, substantial in one sense but relatively small in comparison with the size of the problems to be solved, the returns are already considerable (Rockefeller Foundation, 1949).

The funding of research, development, and expansion of MVs in Mexico could be inferred that it was a bilateral type of project and the grant was *unrestricted* grant (available for the use toward any purpose—the opposite term is *restricted* fund/grant means the use of the fund to a particular purpose and project) based on the two quotations above. In fact, for the case of India, in the early 1950s, there were only five categories of grants that RF offered; Medicine and public health, natural science and agriculture, social sciences, and humanities. Moreover, the grants were offered to the agencies and/or individuals (colleges, schools, institutes, research centers, and universities/ fellowships, scientists, plant morphologists, etc), not to the each project (Rockefeller Foundation, 1952).

On the other hand, research, development, and expansion of NERICA have been implemented through multilateral cooperation, and ratio of restricted grant exceeded half of the all grant (Figure 19 and refer to Appendix F for the detail numerical data). Moreover, the donors that provide the unrestricted grants are the major developed countries and international

(unit: USD)

	2001	2002
Total restricted grants	4,796,839	5,158,657
Total unrestricted grants	4,272,622	4,426,755
Total	9,069,461	9,585,412

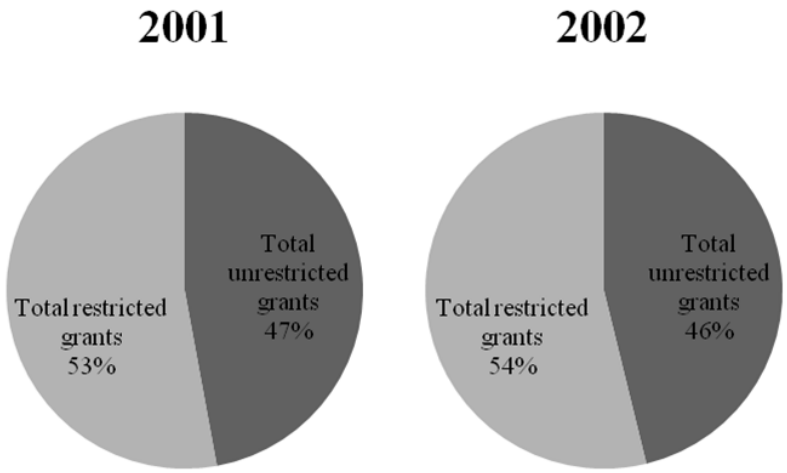


Figure 19 Grants for the year ended 31 December 2001 and 2002 of WARDA
(Source: WARDA Annual Report 2002-03)

agencies, for instance, Belgium, Canada, Denmark, France, Germany, Japan, Netherlands, Norway, Sweden, USAID, WB, whereas the restricted grants were furnished by approximately 50 donors; some donors are overlapped with unrestricted grants donors. In addition, another feature of the restricted grants' donors is that one donor agency is segmented by a name of projects and programs (i.e. Japan offers 11 different projects by several sectors under Japanese government) (WARDA Annual Report, 2003). Although a certain bias must be acknowledged for this comparison (because unlike the RF quotation about the finance shown above, this data includes the grants for not only projects and programs related to NERICA but

also other agricultural development), it is still possible to infer that the AfricaRice's grants have become more restricted, and international cooperation has been required more than before.

To apply the organization theory, assuming that financial constraints limit the projects' and individuals' discretion, the research, development, and expansion of NERICA are financially restricted and therefore, more mechanistic than semi-dwarf wheat which was unrestricted and even individual could be a recipient of the grants.

5.3.2 Manifestoes and mission statements

Stakeholders, especially donors, and research and development agencies generally have a manifesto and goal of the organizations that define their task(s) and role(s) of how to interact with LDCs and/or what to achieve through their international cooperation and development aids. In case of semi-dwarf wheat, there are three major stakeholders: RF, Ford Foundation (FF), recipient's governments.

What kind of manifestoes did RF had during the time of semi-dwarf wheat? RF had the central historical mission of "to promote the well-being of mankind throughout the world," and under such mission, a manifesto of RF and a goal to intervene LDCs at that time were;

> …the RF recognized that food production would be crucial to international peace. […] As RF Trustee John D. Rockefeller 3rd observed, "Hunger as a basic problem has now succeeded disease." […] agriculture became a principal means for the Foundation to

fulfill its mission. It was the RF's first and only direct operating program outside the International Health Division (IHD)[16]. (Rockefeller Foundation Archive Center)

RF recognized that food production would be crucial to international peace and aimed to realize the eradication of hunger to avoid future international violence. Another reason behind that mission was RF had been "promoting agriculture along with public health though no definite organization was developed within its structure dedicated solely to agriculture (Harrar, 1951)." In sum, RF's mission was to promote the well-being of mankind throughout the world and to realize it through eradicating hunger, agriculture was promoted. Closely, as for FF, Henry Ford II, a chair of FF in 1943-1976, "sought in nearly every major decision to create an institution of the highest order to pursue innovative solutions to the problems of humankind (FF[17])."

On the other hand, what recipient's government, for instance, Mexican government sought into the agricultural development was to "modernize Mexican farming and boost the economy, making Mexico more open to U.S. aid (Rockefeller Foundation Archive Center[15])." In addition, looking at the individual programs, for example, the original mission of the High Yielding Varieties Programme (HYVP) in India was "India's Food Crisis and Steps To Meet It

[16] "The International Health Commission (IHC) was created on June 27, 1913, charged with the " … promotion of public sanitation and the spread of knowledge of scientific medicine … " Throughout its history, the organization underwent a variety of mandate and name changes, becoming the International Health Board (IHB) in 1916 and the International Health Division (IHD) in 1927. Ultimately, the organization initiated programs in over 80 countries."
(Source: Rockefeller Foundation: http://rockefeller100.org/exhibits/show/health/international-health-division-)

[17] Ford Foundation History Overview: http://www.fordfoundation.org/about-us/history

(PEO Study, 1971).” Behind of those missions to achieve the agricultural development was to decrease the imports of foods by increasing the food products:

> During the first ten years of independence, India sought to foster social equality. Imperial farms were broken up and redistributed to peasant workers. The new landowners were encouraged to adopt modern technology, but they lacked adequate funds and training to make use of scientific advances. Furthermore, rice had been the Indian dietary staple, but the most productive growing regions were in now-separate Pakistan. India began to import much of its food, buying rice from Pakistan and wheat from the United States. But the fledgling nation needed to develop its own resources (Rockefeller Foundation Archive Center[15]).

In that sense, mission statements and manifestoes held up by the each stakeholder were diverse and decentralized due to the different motivations and background believes. Thus, in other words, during GR, stakeholders participated to the research and development of MVs network to realize their own missions and goals. On the other hand, as for the stakeholder of NERICA, their mission statements and manifestoes are similar to each other, because they lost diversity when the missions and manifestoes are established. The representative examples follow.

ARI (Africa Rice Initiative: launched in March 2002, aims to scale up the dissemination of NERICA throughout sub-Saharan Africa) which is in the position of ‘shuttle breeding network (Figure 18),’ its mission is to “fight poverty through the dissemination of NERICA, ARI is in line with the New Partnership for Africa's Development (NEPAD) and is an

important follow-up to the Tokyo International Conference on African Development (TICAD[18]) (ARI[19])." The implementation system of NERICA does consist of diverse stakeholders, however, it might be no exaggeration to say that those stakeholders have been gathered by sole goal of 'eradication of poverty' which is stated by the MDGs[20], or in other words, the stakeholders state 'eradication of poverty' to legitimate the NERICA implementation. A notable example could be found in the Coalition for African Rice Development (CARD) which is an initiative to support the efforts of African countries to increase rice production. Its goal is to "double the rice production of Sub-Saharan Africa within a decade, [and] CARD seeks to improve rice production overall in terms of both productivity and capacity, by selectively applying rice varieties suited to three cultivation systems: irrigated fields, rainfed lowlands and rainfed uplands (JICA, 2012) (Figure 20)." This mission has been announced at TICAD IV and established based on the concept of MDGs' first goal; 'eradicate extreme poverty and hunger (JICA, 2012).'

Moreover, even NERICA itself emphasizes how it is suitable to achieving MDGs; "the development of NERICA through the partnership-owned Research for Development system has helped WARDA in addressing the United Nations Millennium Development Goal (MDG)

18 The Tokyo International Conference on African Development (TICAD) process is an international forum related to the development of Africa, which was started in 1993 on the initiative of the Japanese Government (JICA, 2012).

19 http://www.africarice.org/ari/default.asp

20 The United Nations Millennium Declaration was adopted during the Millennium Summit held in September 2000, in which 189 countries participated.[…] MDGs were established as a common framework by integrating the Millennium Declaration and the International Development Goals (JICA, 2012).

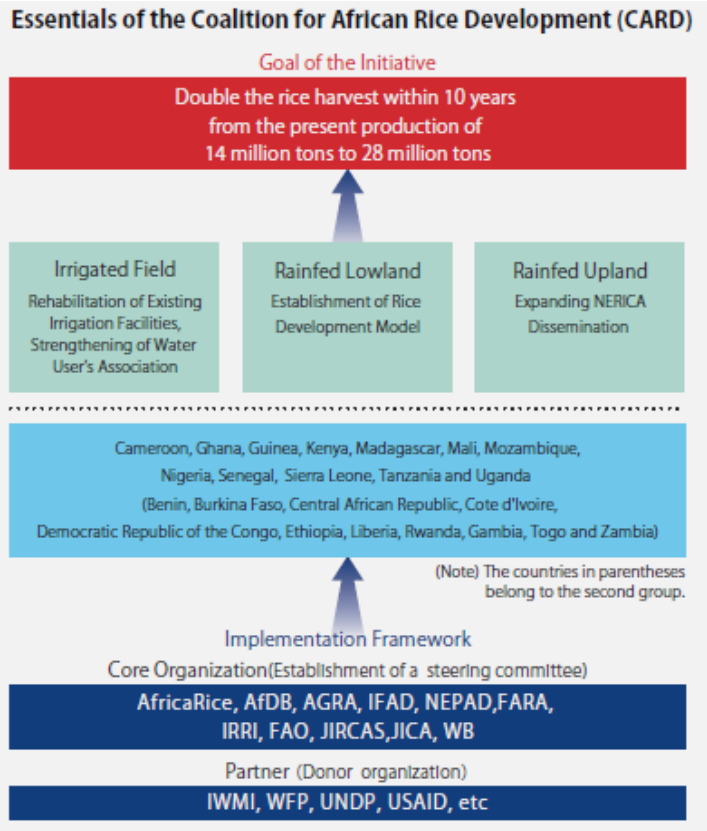


Figure 20 Framework of the goals of CARD

(Source: JICA, 2012)

priorities (Guei, *et al*, 2008).” According to the compendium of NERICA, NERICA can contributable to all eight MDGs. Thus, for the case of NERICA, individual and specific motivation by each stakeholder could not be found or expressed at all. As a result, NERICA’s implementation is summarized and centralized into the internationally justifiable and acknowledged statement, such as ‘to increase food productivity’ and ‘to eradicate poverty.’

Therefore, as for the implementation of semi-dwarf wheat, missions of donors and wills of recipient’s governments were diverse based on their own believes and needs, whereas for the case of NERICA, the manifestoes and missions of each stakeholders are summarized in

MDGs and internationally justifiable statements. Centralization and decentralization are the one significant feature to indicate whether the organization is mechanistic or organic. Hence, looking at the manifestoes and mission statements of NERICA, goal/purpose(s) of organization is centralized into the international goals and individual missions are seemed to be undermined. Contrarily of each stakeholder, NERICA consolidated to MDGs, and it is another evidence that NERICA implementation system is the mechanistic form whereas semi-dwarf wheat is organic form.

5.3.3 Behaviors and communications of stakeholders

Lastly, how do the inner members of each implementation system behave and communicate differently? This part focuses on the several representative behaviors and communications found in the official reports and papers that are disclosed by donors.

■ Communications between donors(developed countries) and recipients(LDCs)

Looking at the reports and documents, the inner members of each implementation system (of semi-dwarf wheat and NERICA) demonstrate different features. The quotation shown below is extracted from ‘Recommendations of the commission to survey agriculture in Mexico’ that American researchers are reporting the results of preliminary research on agricultural practices in Mexico to the Mexican government.

"It is the unanimous opinion of the Rockefeller Agricultural Survey Commission to Mexico that there is urgent need for improving agricultural conditions and practices, […] substantial improvement could be accomplished with even a moderate amount of help from an outside and independent agency, such as The Rockefeller Foundation. […] this situation is not unique in Mexico and can be remedied by the Mexican themselves. […] It can be, and probably should be, amplified and expanded in several directions."
-Recommendations of the commission to survey agriculture in Mexico (Rockefeller Foundation, 1941)

This quote could be meet the definitions and characteristics of the organic form: 'elastic and solution-oriented tasks,' 'minimize rule-bounded behavior,' 'joint-decision making with consensus,' and 'communication between different ranks is consultation rather than command' by expressing the results of the preliminary research as '*opinion*,' rather than just expressing '*result*.' This is because the donor is being ready to accept counter argument(s) and in other words, it shows an attitude of compromise. Moreover, the line of '*It can be, and probably should be, amplified and expanded in several directions*' is a clear performance of organic form because the researcher from the donor side acknowledged the necessity of discussions with the recipient and modification to his solution. That certifies that the inner members of semi-dwarf wheat implementation system fulfill the features of organic form; 'minimize rule-bounded behavior' enable the donor to be 'low formalization,' and 'joint-decision making with consensus' with recipient side, the Mexican government.

In contrast, the way of responding to the recipient's request is different for NERICA. The quotation below is found in a report of the project evaluation from donor side. When SSA country asks specific favors to donor, donor answers the conditions/qualifications to realize the favor. Hence, the donor's behaviors could be categorized as rules-regulations bounded one.

"June 6, Ministry of Foreign Affairs. […] Minister of State asked a question that 'Uganda prioritizes fostering private sectors, so, is it possible to have JOVC (Japan Overseas Cooperation Volunteers[21]) in such sector?' Out team leader answered that 'it is possible only if a public sector accept JOVC at first, then, he/she might be able to work in the private sectors.' […] June 8, National Council of Sports. […] We had a question from them about JOVC's acceptance such as housing and transportation, and our answer was recipient side needs to be responsible for all these."
- Evaluation Reports, 2-3. Results of evaluation (author translation based on JICA, 2010)

Two lines, '*it is possible only if a public sector accept JOVC at first,*' '*our answer was recipient side needs to be responsible for all these*' could be representative for 'formal body of rules to govern the organization' and 'rigid restriction on tasks, commissions, and rules and regulations' that are the typical tendencies of mechanistic form, because compromise or flexibility of donor to the recipient country cannot be found from this quotation,

[21] "JICA's volunteer programs support activities by citizens who wish to cooperate in the economic and social development as well as the reconstruction of developing countries. Widely recognized as a representative Japanese international cooperation program, volunteer activities have not only earned high acclaim from partner countries but are also receiving increased praise in Japan, where expectations for these programs are also rising." http://www.jica.go.jp/english/our_work/types_of_assistance/citizen/volunteers.html

To sum, the case of semi-dwarf wheat and its flexible manners of the inner member is described as organic, whereas inflexible manners of NERICA is described as mechanistic.

■ Personal discretion and reporting format

Following three quotations are the other examples of how personal discretions are maximized in the implementation of semi-dwarf wheat;

"*Since our telephone conversation of yesterday morning I have studied further all of the material on the proposed report to Mr. Barnard from the Advisory Cocmittee on Agriculture. It now seems to me that in view of the importance of this report[…] There may be factors of which I am unaware but as I understand the situation.*"
-Letter from J. George Harrar to Warren Weaver, June 20, 1951 (RF, 1951)

"*I would differ from Professor Stakman on two points. I would recommend […]Are we really ready at this time to try to formulate more or less universal conclusions from our experience in agriculture? […] In short, it seems to me that the Foundation needs to go further in experimentation.*"
-Memorandum by Prof. Stakman, January 12, 1954 (RF, 1954a)

"*From this casual conversation was forged a remarkable partnership between the two foundations that over the next decade laid the basis for the international agricultural research system that is now in place. (Baum, p. 15)"* (McCalla, 2007)

The first quote expresses that reporting through informal communication of the inner members who are at the different ranks. The conversation is 'informal' since George Harrar started writing a letter with '*Since our telephone conversation of yesterday morning I have studied further…*'. Moreover, his position in the organization was field director for agriculture that was lower than Warren Weaver who was a director, and the conversation is frank enough

to show lateral relationship of them. Similar tendency could be found in the second quote, '*I would differ from Professor Stakman…I would recommend…Are we really ready..?*' and those sentences represent a fact that Prof. Stakman is challenged by the other researchers who are at the lower rank. More importantly, the first and the second quotations are from official reporting documents that meant they are treated as the materials to decide the directions of the projects. In fact, referring to the third quotation, McCalla expresses the conversation was casual during the time of GR.

On the other hand, the quotation below is from JICA's report about the NERICA adoption in Uganda. When the researchers and consultants submit the report, they have an official format and the table of contents is already set. Thus, any facts that could not be fit under those titles, are hardly appeared in the report. Such formal and written communication is the one representative feature of mechanistic form.

"*Results of Evaluation*
3-1 Confirmation of Results
(1) Output
Output 1 : Achieved
Output 2: Achieved
(2) Achievement of the Project Purpose
(3) Implementation process
3-2 Summary of Evaluation Results
(1)Relevance
(2) Effectiveness
(3) Efficiency
(4) Impact
(5) Sustainability […]

3-5 Conclusion
3-6 Recommendations"
(JICA. Summary sheet,2011)

From those quotations, the most significant fact is not about the small differences in the terms and words that the members used, but the accumulative facts that there are either organic or mechanistic atmospheres and milieux could be existed and shared in each implementation system. That leads to conclusion that in the semi-dwarf implementation system, more organic features are observed while in the NERICA implementation system, more mechanistic features are observed.

Burns and Stalker state that the organic forms perform more efficiently under the unstable conditions, for instance, competitive market and engineering industries with continuous technological development than the mechanistic ones do. In that sense, agricultural research and development that require early results (for example, 'shuttle breeding' is a standardized methodology to promote MVs development with the objective of speeding the process by growing two successive plantings per year) are characterized as 'unstable conditions,' thus, the organic forms are more suitable to the MVs implementation system from the theoretical aspect. Looking at the characteristics of the implementation systems based on the analytical findings, the implementation system during GR which achieved higher adoption rate had more organic tendencies, particularly for its contents (budget allocation, mission statements, and behaviors of stakeholders).

The holistic conclusions for this section are that implementation system of semi-dwarf wheat demonstrates the mechanistic structure (shown by the organization charts) while it was organic for the contents, whereas NERICA demonstrates the organic in its structure while it is mechanistic for the contents. Hence, the organic forms of contents possibly contributed to the higher adoption.

On the other hand, NERICA implementation demonstrated more mechanistic features though its structure shown in the organization chart is organic. From this study, it is not easy to construe the organic structure as positive impact on the adoption rate. At least, as the structural differences of the implementation system have been discussed in the previous section so far, they are results of accumulative efforts and findings of development economics that respect the self-help effort of LDCs, and other factors from international transitions. Therefore, it is difficult to simply deny the organic structure and promote mechanistic one with this study. However, in terms of contents, the organic forms should be recommended to implement MVs.

5 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

This study aimed to indicate the cause(s) of low adoption of NERICA by comparing it to the adoption of semi-dwarf wheat, and my conclusions based on the three analyses (domestic social conditions, international social conditions, and MVs implementation systems) are that the domestic social conditions such as hunger and poverty, population pressure, and demands for grains are not the major driving factors to increase the adoption rate since the significant differences between semi-dwarf wheat and NERICA could not be observed. On the other hand, the implementation systems of both MVs demonstrate the differences, and those differences are seemed to be originated to the differences and the transitions of international social conditions. Moreover, looking at the implementation systems further with the organization theory, although NERICA implementation system achieved organic structure in the organization chart, the contents (budget allocations, manifestoes and mission statements, and behaviors and communications of stakeholders) demonstrate the mechanistic characteristics, whereas the contents of the semi-dwarf wheat implementation system could be identified as organic. Since Burns and Stalker (founders of the organization theory) states that organic forms are more suitable for unstable and changing

conditions, for instance, engineering industries that experience the continuous technological development, the implementation system with the organic contents are suitable to the adoption of MVs. Therefore, the cause of NERICA stagnation could be identified as the mechanistic contents of the implementation system.

Due to the fact that a participatory research could not be conducted to observe the relationships in the individual stakeholders for the semi-dwarf wheat implementation during the Green Revolution (GR), this comparative study focused on the information which is officially disclosed under status quo. However, to reveal the practical conditions in the field of MVs implementation further, the participatory research on the individual stakeholders such as workers, scientists, and consultants is recommended. By doing so, the conclusion made by this study will be strengthened or developed at a practical level. Hence, in order to clarify the current status of the implementation of MVs futher, a possible future work will be a participatory research such as study on power balance and organization conflicts within inner members.

5.2 Recommendations

Theoretically, the conclusion leads that the unrestricted behavior of stakeholders increases the efficiency of MVs implementation system, meaning that an organic form in both structure and contents is recommended. Hence, what donors could improve in their approach

for development aid and MVs implementation is to increase unrestricted grant and to maximize each member's ability to use his/her discretion on projects and programs. Nevertheless, I have to acknowledge that in the reality, such fundamental improvements have tremendous obstacles to be realized, since numerous past challenges and failures have been accumulated behind the present implementation system which has many rules and regulations to bound organic practices. However, this research can suggest a beneficial effect of organic practices for example, to raise the fund for research, development, and expansion of MVs, LDCs' government and an agricultural research network, such as CGIAR and AfricaRice should consider to approach a private foundation that tends to have the organic structure and content, rather than foreign countries' government and international public agencies.

Moreover, this research suggests another possibility that we should reconsider a taboo of development aid that a top-down and bureaucratic form is anti-humanitarian approach and will always fail. For example, the mechanistic form, in other words, previous top-down and bureaucratic structure of the implementation system has also positive aspect; it structurally decreases a possibility of bribery while increasing discretion of the individual donors because the donor's authority over the project increases. During GR, it is inferred that bribery was not structurally easy to occur or to be exposed, because recipient countries received the only end product of the development aid which is semi-dwarf wheat, thus, they did not have authority in the management process of the research, development, and expansion due to its

mechanistic structure. Furthermore, since the evaluation system for the fund management had not been necessary, consolidated or obligated, bribery would not be significant unless donors considered it is detrimental. Therefore, the top-down approach of development aids might not be a nemesis but effective to increase the MVs adoption, as long as the organic form of content is guaranteed.

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Appendix A

Under-five Mortality Rate (U5MR)

unit: per 1000 live births

	1960	1980	1994
Mexico	148	87	32
India	236	177	119
Pakistan	221	151	137
Benin	310	176	142
Burkina Faso	318	246	169
Burundi	255	193	176
Cameroon	264	173	109
Central African Rep.	294	202	175
Chad	325	254	202
Congo	220	125	109
Zaire	286	204	186
Cote d'Ivoire	300	170	150
Ethiopia	294	260	200
Eritrea	294	260	200
Gambia	375	278	213
Ghana	213	155	131
Guinea	337	276	223
Guinea-Bissau	336	290	231
Kenya	202	112	90
Liberia	288	235	217
Madagascar	364	216	164
Malawi	365	290	221
Mali	400	310	214
Mauritania	321	249	199
Mozambique	331	269	277
Niger	320	320	320
Nigeria	204	196	191
Rwanda	191	222	139

	1960	1980	1994
Senegal	303	221	115
Sierra Leone	385	301	284
Sudan	292	200	122
Tanzania, U. Rep. of	249	202	159
Togo	264	175	132
Uganda	218	181	185

(Source: UNICEF statistical tables, 1996)

Appendix B

Arable land Area [ordered from the smallest to the largest as of 2000]

unit: 1000 ha

	1961	1965	1970	1975	1980	1985	1990	1995	2000	2005	2010
Gambia	121	125	130	164	159	169	187	185	280	330	450
Guinea-Bissau	235	235	245	255	255	290	250	280	300	280	300
Liberia	378	373	366	366	371	380	350	350	380	380	450
Mauritania	267	265	278	192	210	300	400	498	488	400	450
Congo	520	518	520	527	488	528	479	475	490	490	500
Sierra Leone	355	375	400	425	450	475	486	485	490	1,295	1,100
Eritrea	N/A	N/A	N/A	N/A	N/A	N/A	N/A	438	560	620	690
Rwanda	485	505	522	686	760	827	880	700	900	1,116	1,220
Burundi	675	756	940	930	930	930	930	940	960	956	920
Central African Rep.	1,680	1,720	1,770	1,820	1,870	1,900	1,920	1,930	1,930	1,930	1,800
Guinea	3,520	3,448	3,329	3,210	3,091	2,972	2,853	2,734	2,149	2,741	2,850
Benin	920	1,000	1,200	1,370	1,500	1,580	1,615	1,790	2,380	2,700	2,540
Togo	1,800	1,800	1,800	1,800	1,950	2,000	2,100	2,200	2,500	2,100	2,490
Malawi	1,300	1,700	1,800	2,000	1,900	2,050	2,250	2,300	2,750	3,200	3,600
Côte d'Ivoire	1,680	1,680	1,700	1,815	1,955	2,380	2,430	3,000	2,800	2,800	2,900
Madagascar	1,925	1,985	2,060	2,296	2,540	2,650	2,720	2,900	2,900	3,000	3,500
Senegal	2,933	3,132	3,148	3,328	3,121	3,110	3,092	2,942	3,050	3,176	3,850
Chad	2,897	2,897	2,897	2,997	3,137	3,130	3,273	3,420	3,600	4,500	4,500
Burkina Faso	2,124	2,159	2,216	2,506	2,745	2,955	3,520	3,390	3,700	4,900	6,000
Mozambique	2,444	2,470	2,785	2,870	2,870	3,150	3,450	3,650	3,900	4,500	5,200
Ghana	1,700	1,700	1,700	1,800	1,900	2,400	2,700	3,000	3,950	4,000	4,700
Mali	1,638	1,658	1,718	1,818	2,010	2,033	2,053	3,339	4,589	5,603	6,261
Kenya	3,500	3,500	3,500	3,800	3,800	4,574	4,990	5,438	4,891	5,264	5,500
Uganda	3,150	3,768	3,780	4,025	4,080	4,900	5,000	5,060	5,300	5,950	6,750
Cameroon	5,000	5,200	5,400	5,550	5,910	5,910	5,940	5,960	5,960	5,963	6,200
Dem. Rep. of Congo	6,400	6,360	6,440	6,545	6,620	6,700	6,670	6,700	6,700	6,700	6,800
U. Rep. of Tanzania	5,200	6,000	7,000	7,000	8,000	9,000	9,000	8,900	8,600	9,700	11,600
Ethiopia	N/A	N/A	N/A	N/A	N/A	N/A	N/A	9,940	10,000	12,364	13,948
Niger	11,499	11,498	11,197	9,776	10,212	9,770	11,036	13,985	13,980	14,148	14,940
Sudan (former)	10,775	11,172	11,665	12,115	12,360	12,600	12,800	16,157	16,233	18,750	18,858
Nigeria	26,400	26,800	27,420	27,500	27,850	28,500	29,539	30,371	30,000	35,000	36,000

(Source: FAO STAT)

Appendix C

Total Population - Both sexes [ordered from the smallest to the largest as of 2000]

unit: thousands

	1961	1965	1970	1975	1980	1985	1990	1995	2000	2005	2010
Guinea-Bissau	596	598	603	694	835	922	1,017	1,125	1,241	1,368	1,515
Gambia	382	409	459	538	630	768	966	1,126	1,297	1,504	1,728
Mauritania	879	984	1,134	1,312	1,518	1,748	1,996	2,292	2,643	3,047	3,460
Liberia	1,143	1,262	1,440	1,658	1,923	2,212	2,127	2,095	2,847	3,183	3,994
Congo	1,040	1,158	1,335	1,555	1,798	2,081	2,389	2,733	3,136	3,533	4,043
Eritrea	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3,213	3,668	4,486	5,254
Central African Rep.	1,529	1,649	1,829	2,017	2,274	2,627	2,935	3,328	3,702	4,018	4,401
Sierra Leone	2,222	2,373	2,593	2,845	3,162	3,541	3,982	3,898	4,143	5,153	5,868
Togo	1,594	1,700	2,097	2,380	2,667	3,161	3,666	4,085	4,794	5,408	6,028
Burundi	2,993	3,213	3,513	3,680	4,130	4,851	5,602	6,087	6,374	7,251	8,383
Benin	2,451	2,602	2,850	3,182	3,611	4,140	4,773	5,651	6,518	7,634	8,850
Rwanda	2,856	3,221	3,749	4,390	5,179	6,081	7,110	5,570	8,098	9,202	10,624
Chad	3,017	3,289	3,656	4,114	4,554	5,151	6,011	6,998	8,222	9,786	11,227
Guinea	3,593	3,823	4,154	4,287	4,407	4,924	5,759	7,565	8,344	9,041	9,982
Senegal	3,131	3,505	4,096	4,786	5,414	6,232	7,242	8,369	9,506	10,872	12,434
Niger	3,345	3,766	4,373	5,071	5,871	6,744	7,788	9,179	10,922	12,994	15,512
Malawi	3,608	3,975	4,531	5,302	6,240	7,268	9,381	9,883	11,229	12,823	14,901
Mali	5,314	5,597	6,034	6,604	7,246	8,010	8,673	9,825	11,295	13,177	15,370
Burkina Faso	4,957	5,284	5,807	6,435	7,212	8,170	9,324	10,692	12,294	14,198	16,469
Madagascar	5,227	5,764	6,549	7,502	8,609	9,785	11,281	13,129	15,364	17,886	20,714
Cameroon	5,525	6,049	6,842	7,838	9,110	10,519	12,181	13,940	15,678	17,554	19,599
Côte d'Ivoire	3,778	4,424	5,416	6,768	8,501	10,495	12,518	14,677	16,582	18,021	19,738
Mozambique	7,800	8,474	9,453	10,620	12,146	13,335	13,547	15,933	18,201	20,770	23,391
Ghana	6,958	7,808	8,682	9,923	10,923	12,872	14,793	16,997	19,165	21,640	24,392
Uganda	7,007	8,014	9,446	10,897	12,662	14,801	17,700	20,831	24,213	28,431	33,425
Kenya	8,361	9,505	11,252	13,486	16,268	19,655	23,447	27,426	31,254	35,615	40,513
U. Rep. of Tanzania	10,373	11,683	13,605	15,978	18,686	21,848	25,479	29,944	34,038	38,831	44,841
Sudan (former)	11,838	13,021	14,766	17,132	20,071	23,543	26,494	30,141	34,188	38,410	43,552
Dem. Rep. of Congo	15,767	17,543	20,267	23,317	27,019	31,044	36,406	44,067	49,626	57,421	65,966
Ethiopia	N/A	N/A	N/A	N/A	N/A	N/A	N/A	57,042	65,578	74,264	82,950
Nigeria	46,913	51,196	57,357	65,141	75,543	85,829	97,552	110,015	123,689	139,823	158,423

(Source: FAO STAT)

Appendix D

Arable land per capita in SSA [ordered from the smallest to the largest as of 2000]

unit: ha

	1961	1965	1970	1975	1980	1985	1990	1995	2000	2005	2010
Rwanda	0.170	0.157	0.139	0.156	0.147	0.136	0.124	0.126	0.111	0.121	0.115
Sierra Leone	0.160	0.158	0.154	0.149	0.142	0.134	0.122	0.124	0.118	0.251	0.187
Liberia	0.331	0.296	0.254	0.221	0.193	0.172	0.165	0.167	0.133	0.119	0.113
Dem. Rep.of Congo	0.406	0.363	0.318	0.281	0.245	0.216	0.183	0.152	0.135	0.117	0.103
Burundi	0.226	0.235	0.268	0.253	0.225	0.192	0.166	0.154	0.151	0.132	0.110
Ethiopia	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.174	0.152	0.166	0.168
Eritrea	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.136	0.153	0.138	0.131
Congo	0.500	0.447	0.390	0.339	0.271	0.254	0.201	0.174	0.156	0.139	0.124
Kenya	0.419	0.368	0.311	0.282	0.234	0.233	0.213	0.198	0.156	0.148	0.136
Côte d'Ivoire	0.445	0.380	0.314	0.268	0.230	0.227	0.194	0.204	0.169	0.155	0.147
Mauritania	0.304	0.269	0.245	0.146	0.138	0.172	0.200	0.217	0.185	0.131	0.130
Madagascar	0.368	0.344	0.315	0.306	0.295	0.271	0.241	0.221	0.189	0.168	0.169
Ghana	0.244	0.218	0.196	0.181	0.174	0.186	0.183	0.177	0.206	0.185	0.193
Mozambique	0.313	0.291	0.295	0.270	0.236	0.236	0.255	0.229	0.214	0.217	0.222
Gambia	0.317	0.306	0.283	0.305	0.252	0.220	0.194	0.164	0.216	0.219	0.260
Uganda	0.450	0.470	0.400	0.369	0.322	0.331	0.282	0.243	0.219	0.209	0.202
Guinea-Bissau	0.394	0.393	0.406	0.367	0.305	0.315	0.246	0.249	0.242	0.205	0.198
Nigeria	0.563	0.523	0.478	0.422	0.369	0.332	0.303	0.276	0.243	0.250	0.227
Malawi	0.360	0.428	0.397	0.377	0.304	0.282	0.240	0.233	0.245	0.250	0.242
U. Rep. of Tanzania	0.501	0.514	0.515	0.438	0.428	0.412	0.353	0.297	0.253	0.250	0.259
Guinea	0.980	0.902	0.801	0.749	0.701	0.604	0.495	0.361	0.258	0.303	0.286
Burkina Faso	0.428	0.409	0.382	0.389	0.381	0.362	0.378	0.317	0.301	0.345	0.364
Senegal	0.937	0.894	0.769	0.695	0.576	0.499	0.427	0.352	0.321	0.292	0.310
Benin	0.375	0.384	0.421	0.431	0.415	0.382	0.338	0.317	0.365	0.354	0.287
Cameroon	0.905	0.860	0.789	0.708	0.649	0.562	0.488	0.428	0.380	0.340	0.316
Mali	0.308	0.296	0.285	0.275	0.277	0.254	0.237	0.340	0.406	0.425	0.407
Chad	0.960	0.881	0.792	0.728	0.689	0.608	0.545	0.489	0.438	0.460	0.401
Sudan (former)	0.910	0.858	0.790	0.707	0.616	0.535	0.483	0.536	0.475	0.488	0.433
Central African Rep.	1.099	1.043	0.968	0.902	0.822	0.723	0.654	0.580	0.521	0.480	0.409
Togo	1.129	1.059	0.858	0.756	0.731	0.633	0.573	0.539	0.521	0.388	0.413
Niger	3.438	3.053	2.560	1.928	1.739	1.449	1.417	1.524	1.280	1.089	0.963

(Source: Authors' calculation based on FAO STAT)

Appendix E

Lists of Africa Rice Center Donors

- African Development Bank (AfDB)
- AfricaRice Member States
- Agence Nationale de la Recherche (ANR), France
- Arab Bank for Economic Development in Africa (BADEA)
- Australian Centre for International Agricultural Research (ACIAR)
- Bill & Melinda Gates Foundation through the International Rice Research Institute (IRRI); Bioversity International; and the Chinese Academy of Agricultural Sciences (CAAS)
- Canadian International Development Agency (CIDA)
- CGIAR Generation Challenge Programme
- Common Fund for Commodities (CFC)
- ESSO-Chad
- European Union (EU) through the International Fund for Agricultural Development (IFAD); and the Centre de Coopération Internationale en Recherche Agronomique pour le Développement (CIRAD)
- Federal Public Service (FPS) Foreign Affairs, Foreign Trade and Development Cooperation, Belgium Directorate General for Development Cooperation (DGDC)
- Food and Agriculture Organization of the United Nations (FAO)
- France
- German Agency for Technical Cooperation (GIZ) and German Federal Ministry for Economic Cooperation and Development (BMZ)
- International Fund for Agricultural Development (IFAD)
- International Fund for Agricultural Research (IFAR)
- Japan (MOFA, MOF, MAFF, JICA)
- Michigan State University (MSU)
- Norway
- Swedish International Development Cooperation Agency (SIDA)
- Syngenta Foundation
- Technical Centre for Agricultural and Rural Co-operation ACP-EU (CTA)
- The Netherlands Organisation for Scientific Research (NWO) through Wageningen UR
- United Nations Development Programme (UNDP)
- United Kingdom Department for International Development (DfID)
- United States Agency for International Development (USAID)
- University of Sheffield
- World Bank

(Source: AfricaRice Official homepage, http://www.africarice.org/warda/donors.asp)

Appendix F

Lists of Grants for the year ended 31 December 2001 and 2002 of WARDA (AfricaRice)

- **Restricted Grants**

unit: USD

	2001	2002
AfDB (Institutional Support)	99,148	9,867
CFC/FAO-Spirivwa Project	88,060	51,162
Denmark (phytosanitary & Seed Health)	34,405	33,062
EU (Crop & Resourced Management)	207,295	14
EU/CORAF Project	74,978	440,676
France (Collaboration IRD)	20,181	63,270
Gatsby Foundation (Containment Facility)	48,625	6,023
Gatsby Foundation (dissemination)	98,431	217,580
GTZ (Projet riz nord)	6,472	
GTZ (Improved Nutrient Management)	95,066	
GTZ (PTDP)	358,903	387,420
GTZ (Periurban Project)	61,665	103,730
IFAD (PADS Project)	388,098	272,277
UNDP/TCDC-IHP Phase 2	161,371	257,078
Collaboration-NTR/HRI	10,519	20,785
Japan (Ecophysiology Project)	48,845	48,973
Japan (Grain Quality)		12,810
Japan (Interspecific Hybridization Project)	606,640	505,365
Japan/MAFF WARDA Project	318,889	252,648
Japan (RYMV Project)	250,281	185,310
Japan (Blast Project)	183,227	46,907
Japan (Project 1.3)		534
Japan (Project 3.4)	106,233	
Japan (Vegetable Production Project)	25,000	
Japan (Gnebank Project)		400,000
Japan (Project 2.1)	98,817	
Norway (Training Project)	180,533	290,501
Norway (SWIHA HIV/AIDSproject)		102,831

	2001	2002
Rockefeller (Post Doc)	38,898	60,054
Rockefeller (Capacity Building)	26,642	89,919
Rockefeller (FPATDD-Mali/Nigeria)	39,445	55,569
United Kingdom (Weed Project)	6,313	4,828
United Kingdom (RYMV Attributed)	139,578	74,260
United Kingdom (RYMV CRF Project)	47,321	5,039
United Kingdom (Soil Degradation CRF Project)	52,871	491
United Kingdom (Seed Priming Project)	25,454	
United Kingdom (INGER-Africa Phase 2	299,009	291,593
United Kingdom (Wild Rice Project)	13,584	2,919
United Kingdom (Root Penetration-University of Aberdeen)	4,707	
United Kingdom (Blast Attributed)	59,539	29,911
United Kingdom (Rice Functional Diversity)	12,236	17,727
United Kingdom (Attributed Project 2.1)		116,641
United Kingdom (Attributed Project 2.2)		243,633
USAID (Network Project)	195,918	232,374
USAID (Impact Assessment Project)	9,026	40,974
USAID (Nigeria Rice Economy Project)	92,718	145,824
UNEP (Farmer Stakeholder Project)		4,686
Miscellaneous Small Project		20,595
Total*	**4,796,839**	**5,158,657**

- **Unrestricted Grants**

	2001	2002
Belgium	131,780	147,565
Canada	452,828	442,655
Denmark	109,311	
France	148,000	161,385
Germany	140,403	140,655
Japan	412,990	804,762
Netherlands	642,008	665,731
Norway	241,434	360,000
Sweden	319,041	357,916
USAID	224,991	225,000
World Bank	1,390,000	1,080,000
Cote d'Ivoire	59,836	41,086
Total	**4,272,622**	**4,426,755**

Total Grant*	**9,069,461**	**9,585,412**

* *[sic]* The noted values of 'Total restricted grants' and 'Total Grants' are different from the calculated values.

(Source: WARDA Annual Report 2002-03)