Norwegian University of Life Sciences
Faculty of Social Sciences
Dept. of International Environment and Development Studies (Noragric)

2014

Noragric Report No. 71

Opportunities for Support to System of Rice Intensification in Tanzania, Zambia and Malawi

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Report commissioned by NORAD under the NMBU – Norad Frame Agreement

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Noragric Report No. 71
April 2014

Department of International Environment and Development Studies, Noragric
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Noragric Reports present findings from various studies and assignments, including programme appraisals and evaluations. This report is prepared for the Norwegian Agency for Development Cooperation, Norad, under the Frame Agreement between NMBU and Norad.

Norwegian University of Life Sciences

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Opportunities for Support to System of Rice Intensification in Tanzania, Zambia and Malawi.
Report commissioned by NORAD under the NMBU-Norad Frame Agreement.
Noragric Report No. 71, April 2014.
Department of International Environment and Development Studies, Noragric
Norwegian University of Life Sciences (NMBU)
P.O. Box 5003
N-1432 Aas Norway
http://www.nmbu.no/en/about-nmbu/faculties/samvit/departments/noragric

ISSN: 1892-8102
Photo (cover): A farmer cleaning an irrigation canal that leads into an SRI field. Jens B. Aune.
Cover design: Berit Hopland/NMBU

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Summary

There is a great potential for increasing the production of rice in Tanzania, Zambia and Malawi. Many of the constraints on rice production are similar for the three countries. Common problems are low quality of seeds, lack of access to inputs, poorly functioning irrigation schemes, poor soil fertility management, weed infestation, low yields and low technical capacity. When System of Rice Intensification (SRI) was compared to traditional rice cultivation more than a doubling of yield is often found. However, these yield increases in the ongoing schemes are not necessarily only attributable to the SRI principles, but rather because of improved management practices like improved seed and better fertilization and weed control. The current socio-economic conditions for intensifying rice are also not very favourable as there is limited access to credit, limited availability of fertilizer, fluctuating prices and poor market access.

SRI is relatively more developed in Tanzania and Malawi than in Zambia but, in general, it is found on a very limited scale. There is no special policy to promote SRI in any of the countries. In Tanzania, SRI is being promoted under the "Big Result Now" program.

Major obstacles to SRI introduction are the poor condition of the irrigation schemes; lack of good quality seeds and fertilisers, hand-pushed rotary weeders, lack of technical capacity on SRI, lack of proper levelling of the fields, lack of assured marketing, and instability of rice prices. Work is already underway in Tanzania (BRN program) and Malawi to promote SRI in selected locations.

We recommend a broad based support to rice producing where SRI can be one of the components. Apart from SRI such a program will need to address the quality of the irrigation schemes, the competence of farmers and extension agents on rice production, input for rice production, infrastructure and marketing issues. If Norway is to support SRI in Tanzania, Malawi and Zambia it would make most sense to link with the on-going initiatives that promote rice intensification in the countries. In Tanzania one option is to link with the "Big Results Now" program as this program focuses on rehabilitation of irrigations schemes and promotion of good agronomic practices in rice cultivation including SRI. In Malawi the entry point could be in the four irrigation schemes that have been rehabilitated so far under the Irrigation Rural Agricultural Development Project (IRLADP) supported by the World Bank (2011-2014). There is also a general need to strengthen the competence on SRI in the education sector as well as in the extension system. Establishment of SRI demonstration plots could be one way to create an interest in SRI.

Upland rice is more important than lowland rice (irrigated) particularly in Tanzania. If rice is to be promoted attention should also be given to upland rice. It probably requires less capital to intensify this form of rice production as there will be no need to rehabilitate the irrigation schemes.

System of Rice Intensification (SRI) in Tanzania, Zambia and Malawi

1. INTRODUCTION

Agriculture forms a significant portion of the economies of all African countries contributing to an average of 30-40 % GDP. It is important both in terms of livelihoods and addressing food security at the household level. Therefore, if properly managed, it can contribute towards eradicating poverty and food insecurity. The major challenges, however, to agriculture development and food security in Africa are climate change, population growth and lack of suitable technologies and capacity (NEPAD, 2013). Africa will have a population of two billion people by 2050. This prediction alone summarizes the scale of the agricultural challenges. A majority of the farmers in Africa, nearly 85 %, are small- holders and vulnerable to climate and economic changes that are already affecting food production. This will also have implications for price volatility and food deficits that affect both global and local markets, as observed in 2008. The year 2014 is the Year of Agriculture in Africa, and the governments intend to use this as an opportunity to accelerate the current drive for food security. However, poor investments in agriculture sector do not bring in desired growth. Sustainable intensification of agriculture to increase productivity is needed to feed the growing population, increase the income of rural households and make agriculture attractive to investments. This is possible by increasing competence of small- holders, providing ready access to inputs, new cropping systems, improving storage, markets, and rural infrastructure.

Climate-smart agriculture (CSA) may be appropriate for promoting agricultural development in the present context in Sub-Saharan African countries. CSA can be defined as a concept that sustainably increases productivity, resilience (adaptation), reduces or removes greenhouse gases (mitigation), and enhances achievement of national food security and development goals. The main emphasis of the CSA programs supported by Norway in Africa, is on dryland agriculture - the dominant farming system in Africa. It is also the system most vulnerable to climate variability. So far, most of the support has been given to conservation agriculture as a form of CSA. System of rice intensification (SRI) is another potential CSA practice that can be relevant for promoting rice production in Africa. This study focuses on SRI**.**

System of rice intensification

The system of rice intensification (SRI) started in Madagascar and has become popular in a few Asian rice-growing countries. In Africa there are only a few scattered initiatives to promote SRI. Rice is a staple food for a majority of the world’s population, and paddy rice production is highly dependent on irrigation. Rice is also an important part of the diet in many African countries, and the consumption of rice is increasing with economic growth and increasing purchasing power among urban populations. Thus, there is an increasing demand for rice both from local markets and for exports, as observed since the 1980s. In some countries, such as Tanzania and Malawi, the governments have started to include rice as one of the major cereal crops to support their future strategies to address food security. With the exception of a few countries that have attained self- sufficiency in rice production, the demand exceeds production, and hence they depend on imports to meet the gap in supply. There is a high potential to increase rice production in Eastern Africa, which is mostly done under rain fed conditions. With increasing risk due to climate change and irregular rainfall patterns, it becomes highly relevant to intensify rice production under irrigated conditions as water becomes a constraint in the future. Systems such as SRI can perform well when water is in limited supply. The system is based on four main principles:

- Early, quick and healthy plant establishment
- Reduced plant density
- Improved soil management through levelling, enrichment with organic matter and weeding
- Reduced and intermittent water applications alternated by drying

Rationale for the review

Norway has supported the development of rice production through various climate-smart rice cropping systems, including SRI, direct sowing and alternative wetting and drying (AWD) technologies in Asia (India, Bangladesh, Vietnam). This has been done in close collaboration with the respective government authorities and research institutions through a partnership with the Norwegian Institute for Agricultural and Environmental Research (Bioforsk). Bioforsk conducts applied and specifically targeted research linked to multifunctional agriculture and rural development, plant sciences, environmental protection and natural resource management. Some of the results from the ongoing projects are now being upscaled by the respective provincial governments (Tamil Nadu and Andhra Pradesh) in India and also included in the state level adaptation strategies. Large- scale capacity building is also a part of these projects where small holders, women and officials are trained in various CSA systems.

2. OBJECTIVE

In line with the Norwegian food security strategy the overall objective of this review is threefold:

- *Establish a baseline on SRI knowledge, policies and practices in three selected countries targeted under the strategy (Tanzania, Zambia and Malawi).*
- *Provide recommendations for technical support/capacity building on SRI to the countries within existing programmatic (research and development) framework supported by Norway.*
- *Propose other activities to strengthen dissemination of SRI to farmers that can't be incorporated in existing programs, hereunder possible donor collaboration under other relevant programs.*

3. METHODOLOGY/SOURCES OF DATA/INFORMATION FOR THIS REVIEW

The present review was undertaken in Tanzania, Zambia and Malawi. A number of relevant national and regional institutions, including research (such as agricultural universities and national research institutes), policy institutions (including ministries of agriculture in the respective countries) and non-governmental organizations formed part of the review.

The team also reviewed relevant literature, policy and program documents and interviewed institutions that provide support to SRI or were involved in rice programs. In addition, the team made field visits to some of the SRI projects in Tanzania and discussed with the farmers and field officers in the area.

A team of researchers from Bioforsk (2) and NMBU (2) visited each of the countries and met with relevant institutions and development/research programs from 23 March to 5 April 2014.

The review team has documented to what extent these countries and regional institutions have:

- Researched on SRI – both previous and ongoing research on SRI
- Capacity on SRI and interest in SRI research, including review of existing programs
- Established programmatic support to SRI (government and non- governmental)
- Institutional knowledge and capacity on SRI
- Policies promoting SRI and relevance of SRI

The recommendations in this report are based on inputs from key stakeholders and institutions working with rice production and SRI systems in the three countries during and after the visit of the team (see Annex 1, 2 and 3 for the list of people and agencies contacted during the visit). A draft report was also sent to selected people from the public and private sector with whom the team met during the review to solicit their comments to the report. The team got valuable input from people in the public as well as the private sector.

The review team has documented the present status of SRI technology and adoption by farmers, the constraints and potentials for SRI and to what extent the current policy and institutional measures are conducive for promoting SRI in the countries.

4. LITERATURE REVIEW

Rice is among the most popular cereal crops grown in some parts of Malawi, Tanzania and Zambia and other countries in Sub-Saharan African, next only to maize. Numerous water-saving technologies for rice have been validated in Asia, though they remain relatively untested and are not yet used anywhere in Africa. Most notable are aerobic rice (Bouman et al., 2007), alternate wetting and drying (AWD) (Belder et al., 2005), and the system of rice intensification (SRI) (Uphoff et al., 2010). Of these, SRI has attracted the most attention. Although SRI originated in Madagascar in the late 1980s it was introduced to other African countries at various periods spanning from year 2000 to 2011. Currently, more than 18 countries in Africa have introduced SRI to farmers, and the practice has inspired many.

Climate change is already adversely affecting the SSA countries. Extreme weather events such as floods and droughts are becoming more frequent, and seasonal rainfall patterns are changing. In the future, these impacts are expected to intensify (Krupnik et al., 2012). The combination of high demand for food, inadequate water for irrigation and domestic purposes as well as the impacts of climate change on food production processes, call for appropriate water saving technologies as adaptation measures. The technologies to be considered should be those that result in low water consumption while producing higher yields (increasing food security) and contribute to mitigate greenhouse gas (GHGs) emissions, and technologies that can be easily implemented by subsistence farmers. One such area of interest is the method of rice cultivation, namely the system of rice intensification (SRI). SRI techniques include transplanting of single young seedlings at a wider spacing, followed by alternate wetting and drying irrigation and mechanical weed control using hoe or push weeders, and the application of organic fertilizers to the extent possible (Figure 1).

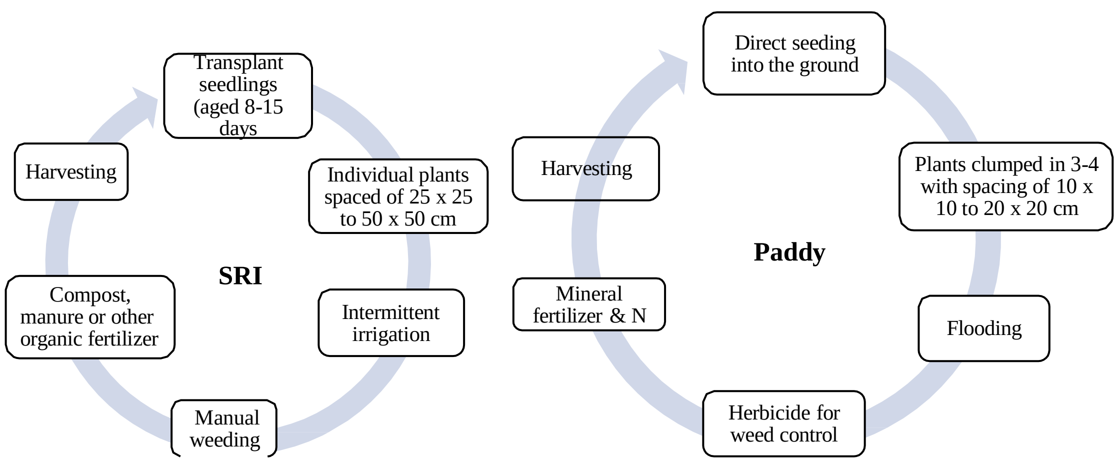

Figure 1. SRI in comparison with conventional paddy rice cultivation systems (Stoop et al., 2002).

Advocates of SRI argue that these techniques provide very high yields and improve water productivity (Stoop et al., 2002; Uphoff, 2007; V&A programme, 2009; Uphoff et al., 2010; Geethalakshmi et al., 2011; Palanisami, et al., 2011; Chowdhury et al., 2012). SRI is increasingly viewed as one of the climate-smart agriculture (CSA) measures and is now supported by institutions ranging from farmers' organizations to non-government organizations and the World Bank. SRI is promoted in 47 countries globally (CIIFAD, 2011), though its popularity has not come without controversy.

SRI has often been a subject of discussion amongst the scientific community with regard to its potential to increase yield and reduce GHG emissions and climate change mitigation (Dobermann, 2004; McDonald et al., 2006). For example, McDonald et al. (2008) showed that SRI yields were not higher than recommended management practices (RMP), and this suggestion spurred considerable debate (McDonald et al., 2008; Uphoff et al., 2008).

The reasons for promoting SRI can be presented as follows:

(i) SRI as adaptation measures to climate change: The system of rice intensification is considered to be a suitable rice cultivation methodology to adapt to the changing climate as it requires less water compared to the conventional paddy rice system. According to Jain et al., (2013) a water saving of 36 % was observed with SRI, and SRI increased the water productivity by 45 % compared to conventional flooded transplanted rice. Other studies also show that SRI can lower irrigation water consumption by 25 % and in some cases reduce fuel consumption used for pumping water by almost 30 litre per hectare (Siopongco et al., 2013).

In Kenya, the average yield under SRI management increased by 1.6 t/ha (33 %), seed requirements reduced by 87 % and water savings increased by 28 %. SRI required 30 % more labour for weeding than flooded rice in the first season, but this was reduced to 15 % in the second season when push weeders were made available to farmers. The results showed that SRI gave a benefit–cost ratio of 1.76 and 1.88 in the first and second seasons, respectively, compared to 1.3 and 1.35 for flooded paddy. Moreover, the results indicated that SRI practices of planting younger seedlings, with wider spacing and intermittent irrigation, leads to increased rice yields with a concomitant rise in the income accruing to farmers (Ndiiri et al., 2013).

In Gambia, SRI management practices with recommended fertilizer application produced a grain yield of 7.6 ton/ha. Computation of production costs showed that SRI production (not needing heavy application of fertilizer) was cost effective (Ceesay, 2011).

One of the reasons for practicing flooding as in paddy rice production is to control weeds. In the Sahel, a study has shown that an average of 27 % (ranging from 18 to 46 %) less water was applied to SRI than required for continuous flooding in RMP, resulting in consistently higher water productivity under SRI. However, when subjected to weed competition, mean SRI yields were significantly lower than RMP in three of four experimental iterations (an average of 28 % less). Weeds reduced the water productivity of SRI by an average of 38 % compared to weed-free treatments. When weeds are carefully controlled, good yields and significant water savings can be achieved with SRI (Krupnika et al., 2013)

(ii) SRI as mitigation measures to climate change: One of the benefits of SRI is mitigating methane emissions. This is because continuous flooding is prohibited in SRI and fields are instead irrigated through alternate wetting and drying (Uprety et al., 2012). Methanogenic bacteria that thrive well in paddy rice fields, produce methane anaerobically. Flooded rice fields are the second largest anthropogenic source of methane emissions after ruminant livestock. SRI can reduce methane emissions by up to 50 % owing to the periodic aeration of soil that inhibits methane-producing bacteria. In the revised IPCC methodology (IPCC, 2006), "multiple aeration," to which SRI corresponds, is presumed to reduce methane emissions by 48 % compared with continuous flooding of rice fields (FAO, 2010). Other studies showed that SRI technology could reduce methane production by approximately 60 % (Uprety et al., 2012).

On the other hand, N_2O emissions could increase under water saving techniques (like SRI) because of increased nitrification and denitrification processes, with soil conditions constantly changing between anaerobic and aerobic and related changes in redox potentials (Zheng-Qin et al, 2007; Sharma et al., 2008). Jain et al. (2013) have reported a higher (23 %) N_2O emission from SRI than from paddy rice. However, data on N_2O emissions from irrigated rice under different water management regimes are limited. There is a trade-off between adaptation and mitigation measures of CH_4 and N_2O emissions from rice soils. In other words, CSA practises like SRI/AWD that reduce CH_4 emissions may increase emission of N_2O from rice soils (Jain et al., 2013).

However, SRI has often been a subject of discussion amongst the scientific community with regard to its potential to increase yield and reduce GHG emissions and climate change mitigation (Table 1). For example, McDonald et al. (2008) reviewed different publications where SRI was compared to recommended management practice and found that SRI yields were not higher than under RMP. This publication has spurred considerable debate (McDonald et al., 2008; Uphoff et al., 2008). However, we find this discussion rather theoretical and not very relevant to the conditions in Africa, as most lowland rice is cultivated under poor management conditions. Any approach that will improve growth conditions will therefore increase yields.

Table 1. Perceptions by promoters of SRI versus opponents of SRI practices.

	Perceptions	*Facts*	*References*
Promoters of SRI	Higher fertilizer use efficiency	□20% increased efficiency	Rao et al. (2013); Thiyagarajan & Biksham (2013)
	Higher benefit-cost ratio	□20% increased benefit	Ndiiri, et al. (2013); Thiyagarajan & Biksham (2013); Veeraputhiran (2012)
	Higher yield	□30% increased yield	Ndiiri et al. (2013); Thiyagarajan & Biksham (2013);Gathorne-Hardy et al. (2013)
	Water saving	□30% water saving	Jain et al. (2013); Ndiiri et al. (2013); Thiyagarajan & Biksham 2013, Veeraputhiran (2012)
	Increased net income	□20% increased income	Ndiiri et al. (2013)
	Less CH_4 emissions	30-60% less CH_4 emissions	Jain et al. (2013); Rajkishore et al. (2013)
Opponents of SRI	SRI had no economic advantage over conventional rice cultivation		Dobermann (2004); Reddy et al. (2005)
	Yields from SRI fields were no higher than RMP		McDonald et al. (2008)
	Increased weed problem in SRI as compared to paddy rice		McDonald et al. (2008)

5. TANZANIA

5.1. INTRODUCTION

In Tanzania, there is a strong interest in modernizing agriculture as expressed in the plan for agricultural development (Kilimo Kwanza). Rice is one of the priority crops for agricultural development. Rice production in Tanzania is expected to reach 1.2 million ton of milled rice whereas the consumption needs are about 1.39 million ton. There is, therefore, a need to import about 200,000 ton of rice in 2013/2014 (ORIZA 2014).

Rice in Tanzania is mainly grown under upland rain fed conditions (about 80-90 %), and about 10-20 % is grown in irrigation schemes. Most farmers in Tanzania practice broadcasting of seeds (practiced both in irrigation schemes and rain fed rice). Only a few practice transplanting methods. In general, rice cultivation is based on low inputs and minimum land and water management. Most irrigation schemes are in a poor condition. A majority of these need rehabilitation including repairs to prevent leakages and cleaning for ensuring water flows. Hence, water cannot be assured for irrigation in the schemes in the present condition, and water is only assured where the irrigation scheme is linked to larger perennial rivers.

Factors constraining rice productivity in Tanzania are poor quality seeds, limited control of water, insufficient fertilization, pest, diseases and weeds. Permanent flooding (paddy rice) as practiced under Asian conditions is rare. If all the principles of SRI are to be followed, it would represent a major shift from the current system of rice production in Tanzania. From the various sources of information gathered during the visit to Tanzania, it is evident that there is a wide gap in rice yields between the actual and potential yields under improved management or technologies (1-2 ton/ha against 6 ton/ha).

SRI has been introduced in recent years in the country, but on a very limited scale. In 2009, the Kilombero Plantations Limited (KPL) initiated a simplified form of SRI for upland conditions. The primary SRI principle practiced is sowing of good quality rice seeds in a 25x25 cm grid. Some hand-pushed rotary weeders were provided to farmers. Other areas where SRI is practiced are in Mkindo and Dakawa in Morogoro and in some isolated pockets in the Mwanza and Kilimanjaro regions. Following the successful implementation of SRI in these regions, there seems to be a growing interest to upscale SRI in other parts of the country.

Saving water is a major reason for introducing SRI in Tanzania as reported during the meetings. If SRI is compared to permanent flooding, there is less water use in SRI. However, the introduction of SRI may not lead to reduced water use in Tanzania as permanent flooding (paddy production) is rarely practiced in rice fields in Tanzania. However, training the farmers in use of alternate wetting and drying as proposed in SRI, may make the farmers aware that it is possible to get good yield without prolonged flooding of rice fields. In order to achieve systems of alternate wetting and drying, it is, however, necessary to upgrade the irrigation schemes to ensure water supply when needed.

Discussions with representatives of the Ministry of Agriculture, Food Security and Cooperatives, SAGCOT and Sokoine University of Agriculture revealed that there is an interest in promoting SRI in Tanzania. The main argument is that SRI uses less water, less seeds and increases productivity. Weeding can also become easier if the rice is planted in rows. However, others actors like the AfricaRice are sceptical about SRI and whether it is relevant at all to farmers in Tanzania who do not have the capacity to adopt such technologies. The reason for this scepticism is related to the additional labour needed to practice SRI and the poor conditions of the irrigation schemes. However, AfricaRice agrees with the principle that intermittent flooding is a good practice for irrigated land. NAFAKA (established under the Feed the Future, a USAID funded project), and NGO that works with the entire rice value chain in Tanzania, is of the view that besides factors related to production, warehousing, credit and marketing should also be taken into consideration in order to improve overall rice production in the country. Both KPL and NAFAKA see price as the major factor that will determine the future of rice production in the country. The current low price makes it less interesting for the farmer to invest in the additional labour needed to practice SRI or any type of rice production. According to NAFAKA, the planting in rows and the transplanting of young seedlings are more labour demanding in SRI.

5.2. POLICIES PROMOTING RICE PRODUCTION IN GENERAL AND SRI IN PARTICULAR

Kilimo Kwanza (Agriculture first) is an important policy document of the Ministry of Agriculture for the promotion of agriculture in Tanzania. The policy document focuses on the modernization of agriculture in Tanzania. One key issue is the creation of an enabling environment for investments in agriculture in Tanzania. Furthermore, Kilimo Kwanza focuses on improving the supply of good quality seeds and fertilisers. The plan identifies rice as one of the key crops for agricultural development. The National Food Reserve Agency will have a role in stabilizing prices of important agricultural commodities.

The government of Tanzania also promotes public private partnership. Southern Agricultural Growth Corridor of Tanzania (SAGCOT) is one example of this focus on private public partnership. SAGCOT is promoting agribusiness development among others by establishing meeting places for investors.

A recent initiative that includes agricultural development is the "Big Result Now" program of the President's Office. This program will rehabilitate 78 irrigation schemes, and SRI will be promoted as one of the approaches for increasing rice production in the country.

There is no particular policy to promote SRI in Tanzania, but in general, there is a positive opinion about SRI in the Ministry of Agriculture.

5.3. INSTITUTIONAL KNOWLEDGE/CAPACITY ON SRI

Despite the advantages associated with SRI, there are challenges related to technological, institutional, financial and policy issues. Nearly 90 % of the farmers in Tanzania are smallholders and produce for own household consumption. One of the challenges is to transplant young seedlings in 25x25 cm grids within 20 minutes after uprooting. In a situation where the seedbed is distant from the rice field, it is sometimes a challenge for the seedlings to be transplanted within this short period. In addition, the seeds are vulnerable to rodents and other pests and therefore integrated pest management is necessary during the rice growing period. With respect to irrigation water requirement, SRI requires less water, but the water has to be available at regular intervals (every 5 to 7 days). SRI therefore requires complete control of irrigation which is not the case in most Tanzanian irrigation schemes (Katambara et al., 2013). Another complication is that if water is not available when the seedlings are ready for transplanting (8-12 days after sowing), then farmers will have to wait. In this case the farmers will have to use old seedling (up to 30 days or more) causing sub-optimal conditions for plant establishment.

Another challenge is to organize the farmers within a particular irrigation scheme, and make them follow a uniform planting calendar, use of improved variety and use of proper fertilization Farmers attached to irrigation schemes will irrigate their rice when water is available. Introduction of SRI will be a challenge in cases of water shortage as the non-SRI farmers are likely to use most of the available water unless there are some agreements in the irrigation scheme. It is easier to introduce SRI if all the farmers in the scheme agree to practice intermittent flooding.

Organic manure is not easily available because the animals are not stall-fed. Weeds appear to be a critical problem in rice production, and we observed traditional rice fields overgrown with weeds (Figure 2b). Weeding in the traditional fields is done by hand, but weeding is difficult because the plants are not planted in rows. Use of mechanical weeding is feasible if the rice is planted in rows.

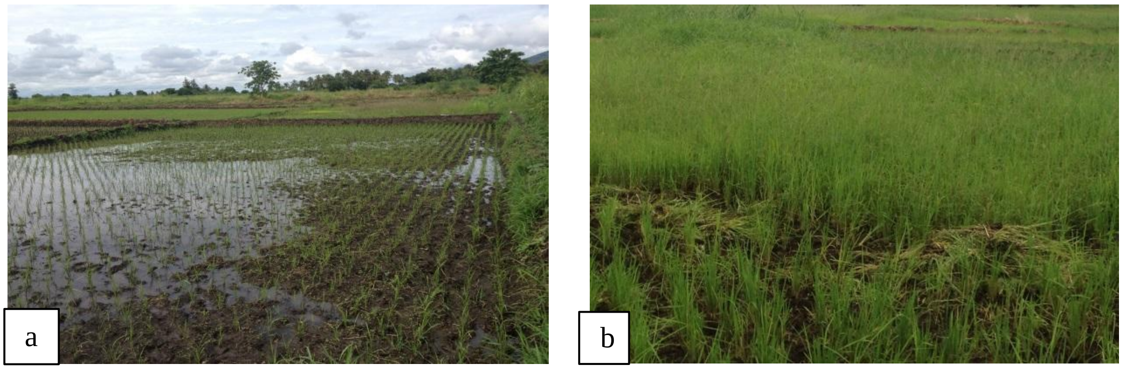

Figure 2. a) Poorly levelled SRI field in Ilonga, Tanzania. b) Serious weed infestation in a traditional rice field.

A condition for successful introduction of SRI is that the irrigation schemes are upgraded. USAID, through NAFAKA, has reserved funds for upgrading an irrigation scheme in Dakawa in the Morogoro region, but the planning and implementation has been slow.

The following were the main challenges identified during the meetings with key stakeholders in Tanzania:

- ***i)*** ***Input supply***- Most farmers do not have access to improved rice varieties and fertilizers. Farmers in some selected areas get two bags of fertilizer at a subsidized rate of 75 % (one bag of urea and one bag of DAP). This quantity is not sufficient for most farmers. They may need at least two bags of urea in the present conditions.
- ***ii)*** ***Poor conditions of irrigation schemes***. Most rice in Tanzania is upland rice, and lowland rice under irrigation is grown under poor management condition. Water is not well regulated in the irrigation channels and the rice fields are not well levelled (Figure 2a).
- ***iii)*** ***Lack of training on the various principles of SRI***. Issues to be covered are land levelling, water management, nursery method, transplanting, fertilization and weeding.
- ***iv)*** ***Lack of organization skills amongst farmers within the irrigation schemes.*** Key issues are agreements on water management, marketing of products and purchase of equipment. Conflict over water occurs in irrigation schemes.
- ***v)*** ***Lack of credit support to smallholders in the country*** is also a limiting factor in the rice value chain. The credit schemes are less interested in providing loans to the farmers this year because of the low rice prices.
- ***vi)*** ***Price policy***. Price variation in rice has made investment in rice production more risky. The Common External Tariff (CET) of the East

African Community is 75 % on imported rice. The EAC protects local industries in a drive toward self-sufficiency. In reality, the CET is porous, and imported rice regularly enters the country duty free, especially through Zanzibar. The Dar wholesale price rose from about 900 TZS/kg in mid-2011 to about 1400 TZS/kg in late 2012, within the cycle of its annual seasonal fluctuation of about 30 %. The Tanzania government, with no forewarning or consultation, exempted 130,000 ton of rice from CET. This resulted in a sudden drop in wholesale price of 54 % by June 2013, followed by another fall of 25 % in August 2014 due to a bumper Tanzanian harvest. The retail price did not fall, however. The market intervention was a serious setback for the farmers, as they could not make any profit on the rice during 2013. At the 2013 harvest, having guaranteed its smallholders 444 TZS/kg of unmilled paddy, KPL paid over the current market price of 260 TZS/kg of paddy, making its smallholder program commercially unviable. Price stability will be a key issue if rice production is to expand.

vii) ***Policy challenges/weak enforcement*** of policies and poor investments. It appears that implementation of polices is a greater challenge than the policy itself. In Tanzania there is a focus on private public partnership and there are examples where such partnerships are working (KPL).

viii) ***Weak extension services***. SRI is a knowledge intensive system, and it will be a challenge to upgrade the competence of the rice farmers across the country.

5.4. PREVIOUS AND ONGOING PROGRAM SUPPORT TO SRI

There is a huge potential to increase rice production in the country. The "**Big Results Now**" (BRN) is the largest initiative for increasing rice production in the country (BRN 2014). BRN is an integrated program involving the 6 ministries (water, education, agriculture, transport, energy, finance) under the Presidential Delivery Bureau (PDB). BRN has several components, and agriculture development is one of them. BRN is promoting three crops, namely rice, sugarcane and maize (2013- 2015). However, for BRN to take off, it needs support from other actors, integration with other departments and also the private sector. The intention is to integrate all relevant sectors to improve the performance under the current National Development Plan. Though the BRN's intentions are good, adequate resources have to be invested, and farmers have to be prepared to meet the goals. Funds for implementing BRN and implementation capacity will be major challenges.

In order to promote rice production under the BRN initiative, 78 rice irrigation schemes have been selected in the country (Morogoro and Southern Highland regions; Figure 3). The objective is to revamp and promote rice production in these areas. SRI is one of the main approaches that will be promoted in selected irrigation schemes. One of the first tasks taken up is training of lead farmers in all the irrigation schemes. Two extension agents and five lead farmers are targeted in each scheme. They will in turn train other farmers on seed selection, water management, fertilization, weed and crop management. Farmers are given a one-week training program. Training of farmers is simultaneously undertaken at rice centres. The Rice Research Centre in Dakawa is supervising the research and training together with District Agricultural and Irrigation Office. The training program for SRI (Jan to April 2014) is intended to introduce farmers to SRI. At Mekindo Farmers Training School, there is also an irrigation scheme where SRI is demonstrated to lead farmers, who in turn are required to demonstrate to fellow farmers. The government covers the costs for the training of the lead farmers.

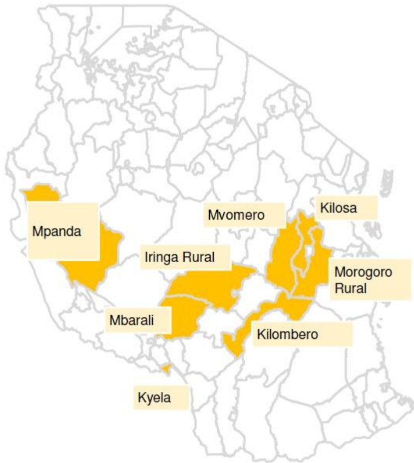

Figure 3. Pilot sites for paddy rice production under "Big Results Now" program.

Kilombero Plantations Limited (KPL) is known as the best example for promoting SRI in the country. However, this is a simplified form of SRI as the only SRI principle practiced is to sow rice at 25x25 cm grid. Farmers have, in addition, got access to improved seeds, new varieties and fertilizer. This a rain fed form of SRI, and yields have increased from 1 ton/ha under traditional rain fed system to an average of over 3.5 ton/ha under SRI, with some farmers, lucky with rainfall patterns or swampy land, reaching 6-8 ton/ha. This yield increase is attributed to pure seeds, improved varieties, less competition between plants, improved soil fertility management and better weed control. This yield increase can therefore not only be attributed to SRI, but is rather caused by improved management in general. Currently, KPL together with NAFAKA works with 6527 farm households in the area to promote rice production. The KPL has established a rice mill where farmers can also sell their rice. NORFUND is providing finance (70 million NOK) for KPL, whereas YARA is assisting in supply of fertilizer.

5.5. PREVIOUS AND ONGOING RESEARCH ON SRI

Literature review showed that very few studies have been carried out so far on SRI performance in Tanzania (Katambara et al., 2013; Tusekelege et al. 2014). The study by Katambara et al. (2013) in Tanzania showed that SRI resulted in higher grain yields and better water use efficiency than traditional rice cultivation. In SRI, higher numbers of panicles and higher numbers of productive tillers were observed.

Currently there are three ongoing research projects involving SRI at the Sokoine University of Agriculture (SUA). SUA in cooperation with Chollima Agricultural Research Institute is conducting research trials on SRI at Mkindo irrigation scheme, Morogoro, in a project (2012 – 2015) funded by the Commission on Science and Technology (COSTEC). The COSTEC funded project conducts trials at three sites for SRI validation at Mbeti, Kilosa, Ilonga. It includes 36 participating farmers. One of the main reasons for introducing SRI here is to reduce the competition for water between farmers. Water is a limiting factor in this area. The research also focuses on variety performance (comparing four rice varieties), seed rates and water usage. Farmers traditionally broadcast seeds at a rate of 30 kg seed/ha, but with the recent introduction of SRI farmers started to use only 6-7 kg seeds/ha. The average yields recorded were 7 ton/ha in SRI as compared to 2-3 ton/ha in the traditional systems. Capacity building is considered as an important component of the project to educate farmers on SRI principles and practices in the field.

Another project at SUA focuses on climate-smart agriculture (Kiroka project funded by FAO). In this project, SRI is being promoted as one of the CSA components along with other crop management practices in rice.

In February 2014, a new project funded by Africa Institute for Capacity Development (ICAD) was approved. This project is expected to provide results to promote SRI in different rice growing areas of the country. The justification for this project is that water availability and water conflicts will become constraints in the future in certain rice growing areas as water is diverted for other purposes like hydropower production. Hence, there is a need for rice production technologies that need less water. The aim here is to develop a SRI management system that can reduce the burdens on farmers and build capacity of small-scale farmers.

The Climate Change Impacts, Adaptation and Mitigation (CCIAM) program of Sokoine Univeristy of Agriculture (funded by the Norwegian Embassy) has rice intensification as one of the component. This project does not particularly focus on SRI, but is conducting research on soil fertility management and weed and pest management. This component is undertaken in collaboration with YARA and Syngenta.

Priority research areas related to SRI and rice intensification in general include appropriate spacing, right age for planting, nursery management issues, transplanting technique, weed control, fertilization in rice (including fertilizer use efficiency), tools for weeding, and water management.

5.6. RECOMMENDATION FOR TECHNICAL SUPPORT/CAPACITY BUILDING ON SRI

Upscaling SRI in Tanzania will be a challenging undertaking as there will be a need for major investments in upgrading of irrigation schemes, training of farmers and strengthening the value chain for rice in general. The recommendations can be summarized as follows:

1. One of the main recommendations that came from meetings with various agencies was the need for targeted training of extension staff and farmers in selected irrigation schemes. It can furthermore be useful to establish SRI demonstration plots. The lead farmers trained should also be supported to practice SRI on their farms. This will enable farmer-to-farmer learning and could provide better results. Farmer field schools should be active to train farmers on SRI, and extension systems should be proactive.

2. There is a need to upgrade the irrigation schemes if SRI is to be correctly practiced. This will minimize losses of water and make sure that water is available on time. Such upgrading of irrigation schemes can be connected to the BRN program, but this is a long term measure and will need heavy investments.

3. Strengthen research on SRI: This includes agronomic aspects like breeding, fertilization, labour issues in SRI and water use. Critical points along the value chain should be addressed: this includes inputs (seeds, fertilizers, hand-pushed rotary weeders), marketing, credit and price issues.

5. Better organization of farmers for harmonized planning the SRI operations. This will allow farmers to carry out planting, irrigating, harvesting etc. the same time. Organization of farmers should happen from within the communities.

The Government does not have the capacity to address all these issues and needs support from other agencies.

There is generally an interest amongst government agencies and other development actors in technologies such as SRI to improve rice production in the country. Farmers in Tanzania are likely to continue to grow rice were the conditions for rice are favourable. Our study has shown that it is possible to greatly increase rice yields in Tanzania through use of better agronomic practices. When comparing SRI techniques to traditional technique the studies show that often there is more than a doubling of yield. We believe that most of the observed increases are related to the introduction of better agronomic practices and not necessarily SRI in the present conditions. These yield increases are related to improved varieties, timely planting, more optimal spacing of plants, more fertilizer and better fertilizer application methods, and improved weed control. We believe it is possible to support rice production in Tanzania and SRI in selected irrigation schemes that should be upgraded, and it can make an important contribution to improve rice production in the country.

However, most rice in Tanzania (80-90 %) is not cultivated under irrigated conditions, and a program on rice intensification should also include upland rice production.

6. ZAMBIA

6.1. INTRODUCTION

In Zambia, rice is grown mostly in three regions: 1) Chambeshi floodplain and dambos, Luapula and Northern Provinces, 2) Upper Luangwa Valley, Chama, Eastern Province, and 3) Zambezi floodplain, Mongu, Western Province (Figure 4). The three areas account for 60, 30 and 10 % of the national production, respectively (2005/06 season). In Mongu and Chama, farmers grow traditional, aromatic varieties with low yield potential. Rice is a staple food in these areas. The aroma and taste of the local rice varieties make them very popular in the market. The Northern Province is known for its upland rice where the improved Nerica[1] variety is being grown. Expansion of rice on the dambos in the Northern Province can be difficult due to the sandy, acidic and nutrient poor soils.

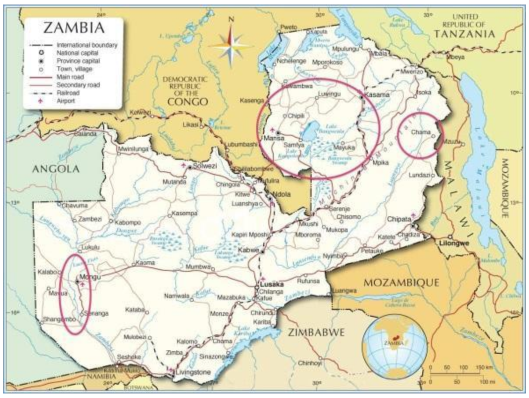

Figure 4. Three rice cultivation areas in Zambia (red circles): 1) Zambezi floodplain (Mongu, Western Prov.), 2) Chambeshi floodplain (Luapula) and dambos (Northern Prov.), and 3) Upper Luangwa valley (Chama, Eastern Prov.) (base map: Vidiani.com).

The three rice-growing areas are located in different agro-climatic regions and under different local conditions in terms of water availability, soils, markets and socio-economic conditions. Accordingly, the challenges to produce and market rice differ substantially. Most rice is grown under either rain fed upland or lowland conditions or under uncontrolled flood conditions. Very little is grown with controlled drainage and irrigation.

Under rain fed dambo conditions, some farmers use treadle pumps to bring water up from the river. Typically, they can bring water to about 100 meter from the river bank with these pumps. Treadle pumps are also used to irrigate vegetables as well. In the Western Province in particular, the flooding can be very variable. Sometimes, rice plants may end up under a meter or two of water. Other times, water may be absent, and young plants may dry out. Improving rice conditions

[1] A cross between the African *O. glaberrima* and the Asian *O. sativa.*

under these conditions is first and foremost a question of regulating water to the needs of the crops. To do so, irrigation and drainage structures are needed. As a result of newly built bunds to contain water in the Mongu area, sand is deposited on rice fields during flooding and thereby reduce rice yields. Managing water structures in the Zambezi floodplain is not easy, according to agencies working in this region (CFU, JICA, CONCERN).

Zambia produces 40,000 ton of its total rice consumption of 65,000 ton. Thus, there is a gap of 25,000 ton between the national supply and demand that is met by rice imports from the Far East. Most of the nationally produced rice is cultivated by small-holders. Rice consumption in Zambia is increasing faster than the production, especially among the urban population, and the consumption will increase further with the economic growth. Besides, there is also a potential to export rice to the neighboring countries, especially the local Chama, Nakonde and Mongu aromatic varieties. Consumers have a preference for the aromatic rice and are willing to pay higher price depending on the size of the grains, colour and absence of grit and other impurities. Therefore, improving the quality of the produce can fetch higher price to small-holders.

The area under rice cultivation has increased in Zambia since year 2000. The country has still a vast potential to increase its rice production. FAO has estimated that out of 2.75 million hectare that has the potential for irrigation development in the country, only 156,000 hectare is currently under some form of irrigation. Rice can be cultivated in areas that are too wet for maize and hence, does not compete with maize for land. The productivity of rice can be increased from the current average of 1.7 ton/ha to at least 4-5 ton/ha. Given the potentials, rice has now become a recognized food security crop in Zambia. The Food Reserve Agency (FRA) has started marketing it in some selected districts. However, these efforts are inadequate and several agencies are looking for investors or donors for help.

In Zambia, many rice farmers cultivate rice very extensively. Much of the current rice production is based on broadcasting, limited land preparation and minimum inputs. Only in upland rice, where Nerica IV variety has been introduced, is fertilizer now being applied. SRI can be introduced among farmers in Zambia as a set of principles adapted to local conditions.

In some areas, particularly in the Western province, many farmers broadcast seeds before the rain, wait for floods and then come back at the end of the season to see if there is any standing crop to be harvested. Rice fields closest to the Zambezi River may at times be damaged by high floods, while fields closest to the upland may suffer from drought at other times. Farmers cannot control or predict the levels and timing of floods. To reduce risks, they plant both low-lying fields and more elevated fields. Fields with optimum water in a particular year will provide the best yields. Optimum flooding also suppresses weeds. The livelihoods of the people in these areas are mostly based on fishing and cattle herding, and rice cultivation is a secondary source of income.

In the Western province, land preparation is done by men using oxen, whereas in the north, land preparation is done with hand hoe – also by men. Planting, weeding and harvesting operations are normally done by women or as a joint effort. Men often cultivate bigger plots away from the homestead and grow rice for sale, whereas women manage smaller plots near their houses and grow rice mostly for household consumption. In some areas, men do most of the work associated with rice cultivation.

The major challenge in rice cultivation is raising productivity among small-holder farmers. They need to produce sufficient volumes at reasonable high quality to ensure food security and exploit markets. Low productivity is due to:

1. Lack of proper inputs - especially pure seeds, high yielding varieties of rice suitable to the different regions, and fertilizers. Most fertilizer subsidies provided by the government are for maize and not rice.
2. Lack of water management structures enabling drainage and irrigation. Facilities that exist need rehabilitation before they can be put to use or introduce the water management systems of SRI.
3. Limited disease and pest control including protection against birds.
4. Lack of tools and machines - rice production in general, and SRI in particular, is labour intensive, and at the moment, small-scale farmers hardly use any tools for rice cultivation. Poor milling facilities lead to high proportion of broken grains and contamination of weed seeds and consequently low price.
5. Poor knowledge of irrigation, soil and water management practices.
6. Lack of market support for small-holder farmers who are not organized and have poor business skills. Although farmers are assured a minimum buying price set by the government that becomes a yardstick for the sale price, rice farmers are often exploited by middlemen. The Food Reserve Agency supports the farmers to some extent by buying some rice, but due to delay in payments, farmers are compelled to sell directly to traders from Lusaka at a lower price.
7. Lack of institutional support – rice currently does not have any special support program from the government like maize. As of late, rice has been partly included in the FISP program.

6.2. POLICIES PROMOTING RICE PRODUCTION IN GENERAL AND SRI IN PARTICULAR

The designation of rice as a significant contributor to food security in Zambia resulted in the formulation of a National Rice Development Strategy (NRDS) in 2011, by the Ministry of Agriculture and Cooperatives (MACO, now MoAL). This is to promote investments in research and development, and encourage domestic rice production. The strategy emphasizes a strategic framework integrating all actors in the rice value chain from production to marketing:

a. Undertake rice varietal improvement through research and by establishing a farmer-community-private sector certified seed production and distribution system;
b. Expanding hectares under both the rain-fed lowland and upland ecologies;
c. Promoting community managed mini-irrigation schemes and integrated farming practices;
d. Promoting adoption of technologies suitable for the various categories of producers and processors in the value chain;
e. Promoting sustainable management of water and soil fertility through adopting *good agricultural practices*;
f. Strengthening domestic market linkages and improving access to business development services and cross-border and/or regional markets; and international markets;
g. Advocacy for a predictable and pro-business trade policy environment that could provide incentives for small-holder farmers and private sector investment in the rice sub-sector;
h. Establishment of a warehouse receipting system, the Agricultural Marketing Act and the Agricultural Credit Act.

The National Rice Development Strategy does not refer to SRI, but uses the term "*good agricultural practices*" (GAP), a broader and more flexible concept.

Other policies that indirectly support rice production in Zambia include the National Agricultural Policy (NAP), the National Irrigation Policy (NIP), Fifth National Development Plan and now the Comprehensive African Agriculture Development Programme (CAADP). The rice subsector has been realigned to CAADP principles, particularly pillar III and IV.

The National Agriculture Investment Plan (NAIP) 2014-2018 (MoAL, 2013) seeks to identify investment priorities and policy changes to lessen the incidence of rural poverty through robust agriculture-led growth. The role of rice is implied, but does not have a prominent position in the investment plan.

The relevance of SRI as a package is currently low in Zambia according to our informants. However, introduction of adapted SRI methods is possible. Transplanting of young seedling, row planting, mechanical weeding and application of manure and compost are relevant relevant practices according to some of the agencies (ZARI, PAM, CFU, Concern). These elements of SRI are already being promoted in some of the ongoing initiatives and considered to be part of the good agronomic practices. For proper implementation of these practices, farmers need proper training and inputs. These techniques are not sufficient, however. A broader range of challenges must be addressed along the entire rice value chain including storage, processing and marketing.

The anticipated climate benefits of intermittent wetting and drying within SRI is not relevant until irrigation and drainage structures are in place, and water can be regulated.

Currently, the primary focus in rice promotion is seed quality, development of irrigation structures, fertilizer management, tools and other aspects of value chain. Upland rice production is given increased attention by promoting the new Nerica variety.
Unlike in maize production, seeds and fertilizer for rice cultivation are not subsidized. Rice is largely a *free market crop*. Rice was to some extent included, though, in the Farmer Input Support Programme (FISP) three years ago.

Policy institutions urge donors to use the National Investment Plan (NIP) as a guide for investment priorities. According to the institutions, it is regrettable that some donors appear to follow instructions from their head offices rather than align their support to the investment plans.

6.3. INSTITUTIONAL KNOWLEDGE/CAPACITY ON SRI

SRI is generally known in the Ministry, University, research institutions and some NGOs. On the other hand, some NGOs dealing with rice cultivation are not aware of the SRI term, but promote some of its elements as *good practices*. The following institutions working with rice were contacted during the visit to Zambia.

Misamfu Regional Research Station near Kasama, Northern Province, has a rice research department focusing primarily on research in upland rice. Research is being done on variety trials of imported, improved varieties. The station wants to move forward by also studying options for mechanization.

The JICA supported project “Food Crop Diversification Support Project, Focusing on Rice Production (FoDiS-R)” takes into account all rice cultivation technologies, including those of SRI. However, the project does not use the term “SRI” and does not specifically promote the elements of SRI above other options for good cultivation practices. According to project staff, they consider all relevant cultivation options when they design recommendation on the basis of local conditions.

The University of Zambia does not have academic staff specifically dedicated to rice cultivation. Rice is a relatively new crop and not much research and teaching capacity has been developed so far. Rice can be ranked fourth after maize, sorghum/pearl millet and wheat in terms of research and teaching.

In general, farmers tend to adopt row planting since it gives better yield and makes liming and fertilization more targeted and makes weeding easier.

The term ‘rice intensification’ includes all aspects of rice production to most stakeholders contacted, not only the four principles of SRI derived from Madagascar. According to consulted staff, rice intensification should also include improvement of varieties, water management, marketing, pest control, training and more.

6.4. PREVIOUS AND ONGOING PROGRAM SUPPORT TO SRI

CONCERN promotes elements of SRI among small-scale farmers in the Mongu area. Introduction of rice nurseries, early transplanting and row planting has given promising results with substantial yield increases. Weeding is done by hand whenever water does not suppress the weeds.

A voluntary advisor to the Esek Farmers' Cooperative Society carried out SRI trials in 2006 on the west bank of Zambezi in the Western Province. The demonstrations showed an increase in rice yields and higher water use efficiency. It was quite interesting and encouraging for local rice farmers to observe the SRI demonstration plot, which gave an average yield of 6.1 ton/ha. Later, demonstrations were made on upland conditions. The effects are mainly due to the planting method and application of manure.

The large-scale JICA project focuses on dambo areas since they are wet beyond the rainy season. Lowland irrigation schemes are currently too advanced for novice rice farmers in remote areas, let alone the details of SRI. The JICA project considers SRI as a "*high risk and high return*" system. The risk is primarily linked to the vulnerability of the young transplanted seedling and their low survival rate under uncontrolled floods, which are quite common, particularly in the Western region.

In order to improve rice production and introduce systems like SRI, the land with irrigation potential should be explored first, as well as investments to develop irrigation infrastructure. Agronomic practices involving higher inputs, labour, technology and management should be carefully introduced along with capacity building of farmer groups through targeted training, close follow up and provision of inputs. Zambia has high levels of rural poverty, and farmers are mostly of subsistence nature and have not effectively captured the overall improvement in Zambia's economic performance. Reaching these small-holder groups and train them to adopt improved systems will be a big challenge.

There are a few agencies working with rice and intensification of rice production in the different provinces in Zambia. In Western Province, the Program Against Malnutrition (PAM) supply seeds and also buy up rice from farmers, but on a limited scale. CONCERN and PAM are promoting rice planting in rows rather than broadcasting and training farmers to use nurseries and row transplanting and thus obtain optimum plant density. Normally organic manure is added, but for rice, PAM recommends top dressing that can be supplemented through urea. At the same time training is given to farmers for imparting knowledge on application of manure and soil management for better yields. In their project areas, CONCERN and PAM have observed increase in average yields from about 1 ton/ha with traditional broadcasting and without inputs, to 3 ton/ha after improvement of cultivation methods. The increased yields can be attributed to plants in rows, better spacing, addition of manure and lime and proper weeding.

COMACO is an NGO based in Lusaka helping rice farmers to market their products. In 2013, COMACO bought about 2500 ton of rice from small-scale growers. COMACO is planning to work with the SRI group from Cornell University (N. Uphoff and E. Styger). They will introduce a modified form of SRI in the Eastern Province. COMACO is promoting two rice varieties, Chinsala and Chama. They also emphasize training of lead farmers so that they become a source of inspiration for the local communities. COMACO emphasizes dissemination of information through radio broadcasting to promote agriculture and food security, targeting specifically adults in rural communities. COMACO also distributes practical manuals and other promotion materials. With a renewed focus on rice production, COMACO will cover the value chain from production to supermarket delivery.

6.5. PREVIOUS AND ONGOING RESEARCH ON SRI

Research on SRI in Zambia is very limited. The University of Zambia, School of Agricultural Sciences, is currently conducting experiments to look at the nitrogen efficiency in rice using large urea granules. They are also developing new rice varieties through mutation breeding, and they are determining effects of water management on various rice varieties. This year's trial showed better growth with more water. The trials have not tested the full concept of SRI so far.

Since rice is a new crop ranked behind maize, sorghum/pearl millet and wheat, the research capacity on rice production is naturally limited. As a technical element within rice production, SRI is also given relatively low priority. Managing water and nitrogen is important for rice, and there is limited knowledge of how flooded areas can generate methane emissions if not properly managed. The other problem is that the rice varieties available now are not very suitable for the conditions in Zambia, and hence more research and knowledge on these are necessary.

6.6. RECOMMENDATION FOR TECHNICAL SUPPORT/CAPACITY BUILDING ON SRI

Zambia is in an early stage of its development of rice production. Support should not be restricted to the SRI elements of rice production, but should rather encompass the entire rice value chain that will also meet the three objectives of climate-smart agriculture, *food security*, *adaptation* and *mitigation*:

- Develop pure seeds and high yielding varieties of rice and make them available to farmers; include aromatic properties into the Nerica variety *(food security and adaptation)*
- Invest in water control structures – fluctuations in flooding and rainfall are becoming more extreme and difficult for farmers to predict *(food security, adaptation and mitigation)*

- Start “rice out-grower schemes” in the three different provinces and organize farmer groups closely linked to commercial traders for input and output flows *(food security)*
- Demonstrate the benefits of intensification of rice growing in different provinces *(food security and adaptation)*
- Step by step implementation depending on the region (pure seeds, high yielding varieties, introduce row planting, use of low cost and simple tillers and weeders), rather than the package of SRI at once *(food security and adaptation)*
- Provide marketing support, the set price and credit support to farmers by linking the farmer groups with traders *(food security)*
- Some elements of SRI could be relevant in the flood plains in Western Province, as there are some irrigation schemes in this province that are not in good condition, but with some rehabilitation, there is a potential to improve irrigation *(food security, adaptation and mitigation).* Here SRI could be tried in a limited area under controlled conditions and in cooperation with a selected group of farmers, scientists and the extension agencies.

Support can be also be given through NGOs (organizing farmer groups, training, marketing) and governmental agencies (pure seeds, varietal development, fertilizer, research trials, irrigation) on selected issues in the field of rural development, food security and agricultural production. Currently, none of these are specifically targeting SRI as a package. A broad-based support to rice production – containing elements of SRI – and marketing in general, would appear meaningful.

7. MALAWI

7.1 INTRODUCTION

Rice is grown in large parts of Malawi, but mostly concentrated along the western shore of Lake Malawi, around Lake Chilwa and along Lower Shire River in the south (Figure 5). To a lesser extent, upland rice is grown along the smaller rivers flowing eastwards into Lake Malawi.

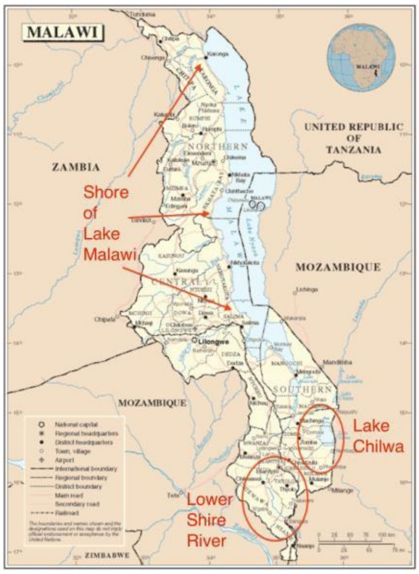

Figure 5. Map of Malawi with the location of the major rice growing areas (base map: Vidiani.com).

According to the Lake Chilwa Basin Climate Change Adaptation Programme (LCBCCAP, 2012), rice is the second most important food crop, after maize in certain rice-growing areas. About 85 % of the rice fields are either rain fed upland or rain fed lowland. Only 15 % are irrigated. In Malawi, local, aromatic varieties are mostly cultivated, such as Kilombero (long grains) and Faya (smaller grains). The Kilombero rice, which is mostly grown in the Karonga District, is particularly in demand due to its long grains and attractive aroma. The value chain is still insufficiently developed for area expansion that could increase production.

During the last 20 years, the rice production in Malawi has doubled from 60,000 ton to nearly 120,000 ton (FAOSTAT, 2014). The increase has primarily been due to expansion of area under rice cultivation from 30,000 to 60,000 ha. During the same time, the average yield has increased by less than 20 %, from 1.6 ton/ha to 1.9 ton/ha (Figure 6). With better agronomic practices and higher inputs, the yield can easily be doubled, bringing the total production well over 200,000 ton per year. The current production does not meet the demand of the domestic market. There is definitely a potential to increase both production and productivity in the country.

Rice production is hampered by lack of pure seeds, lack of improved high yielding varieties, laborious hand weeding, lack of water control, lack of fertilizer, lack of manure, imperfect land levelling and marketing constraints. In some areas where flooding is sufficient, two crops of rice are harvested. In others, one short rainy season provide water for only one crop. Due to risk and limited investments, intensification of agriculture is limited. To promote intensification of agriculture, improving irrigation and land tenure are crucial for Malawi.

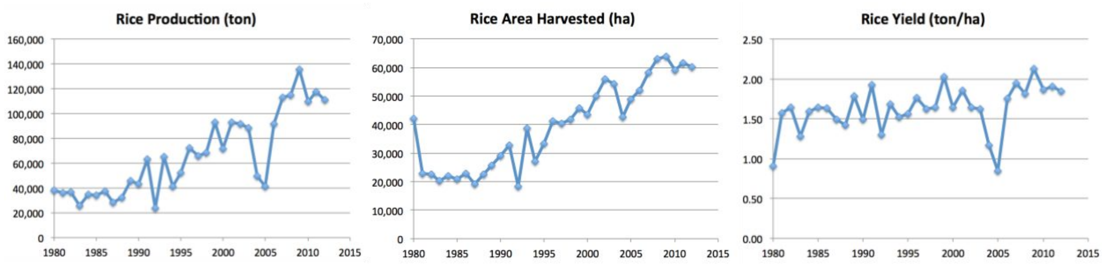

Figure 6. Rice production, area and average yields for 1980–2012 (data from FAOSTAT, 2014).

Most farmers use mixed, recycled seeds leading to uneven crop age and different time of maturity. Farmers prefer ox ploughing to hand hoeing as the latter is more labour demanding. The priority for improvements in rice cultivation is: 1) quality seeds, 2) water control structures, 3) fertilizers, 4) weeding tools, 5) time of planting, and 6) proper spacing. The value chain study in the Lake Chilwa basin by LCBCCAP concluded that farmers should practice seed dibbling method instead of transplanting due to unpredictable rainfall.

Malawi is blessed with large water bodies, rivers, lakes and dambo wetlands. There is large scope for sustainable production expansion for the domestic market and export. Malawi has an irrigation potential of about 162,000 hectare, which is about 7 % of arable land. Currently, only a little over 2 % of arable land is under irrigation (IRLADP). There are about 15 irrigation schemes in the country, built during the 1960-70s with support from Taiwanese, British and other donor agencies, which are suitable for rice cultivation if rehabilitated. Each of them has a capacity to irrigate 250-500 hectare if fully operational.. All schemes have been rehabilitated, the last four under the Irrigation Rural Agricultural Development Project (IRLADP) supported by the World Bank (2011-2014). The earlier ones under the now closed IFAD funded Smallholder Flood Plain Development Project. IRLADP took the IFAD approach further in formalizing irrigation management transfer and formalizing land tenure and providing further training to water user associations. In principle, all 15 schemes are now in reasonable working condition, although in some of the schemes problems of land levelling and lack of measurement/control equipment may persist. Water user associations have been organized in these irrigation schemes. According to the World Bank, rice cultivation in dambos will not give as high yields as in irrigated fields due to short and irregular rain seasons. Control of water, especially drainage, which is essential for SRI, could be possible in the irrigation schemes. Farmers will not invest in rice intensification if the water supply is uncertain.

7.2. POLICIES PROMOTING SRI AND RELEVANCE OF SRI

The Malawi government has not formulated policies specifically on SRI, and rice is mentioned in policy documents only in passing. According to the "Malawi Growth and Development Strategy II 2011-2016" (GoM 2012), one of two goals for the key area "Agriculture and Food Security" is to "*increase agriculture productivity and* *diversification*". One of several outcomes is "*increased production of high value agricultural commodities including cotton, wheat and macadamia for exports*". According to the strategy, maize has remained the main staple food for Malawians, hence national food security has mainly been defined in terms of access to maize. However, other food crops such as rice, cassava, sorghum, and potatoes are alternatives to maize in many parts of the country, complemented by livestock and fish products.

Under the key area "Food Security", the strategy document states that "*the agriculture sector is dominated by tobacco, tea and sugar as the major foreign exchange earners. During the implementation of this development strategy, the country will diversify by promoting wheat, cotton, and coffee and production of fruits and vegetables*". Rice is not mentioned.

The "*Malawi Agricultural Sector Wide Approach: A Prioritised and Harmonised Agricultural Development Agenda: 2011•2015*" (MoAFS, 2011), defines three investment focus areas: (i) Food Security and Risk Management; (ii) Commercial Agriculture, Agro-processing and Market Development; and (iii) Sustainable Agricultural Land and Water Management. Rice is mentioned under the latter focus area as relevant for Component 2 Sustainable Water Management and Irrigation Development:"*... promote the expansion of sustainable water management by improving utilization efficiency and increasing the area under irrigation for increased high value commodity production. The high value crops considered a priority include rice, paprika, chillies, green maize, vegetables (cabbage, onion, tomato, garlic, shallot, green beans, carrots, peas), and fruits (banana, pineapple, citrus, mango, strawberry, pawpaw)*".

The low emphasis on rice is likely due to its low contribution to the production of Malawian staple foods (Figure 7).

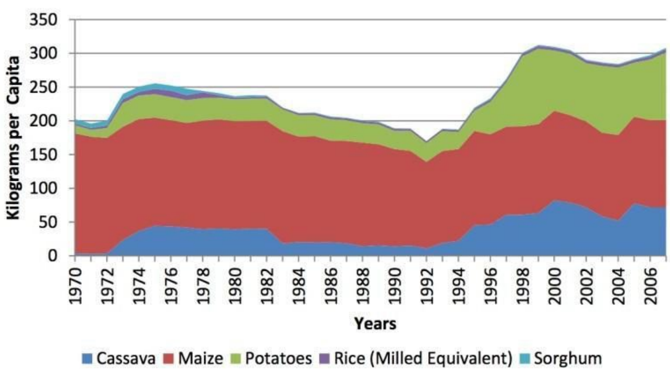

Figure 7. Production of staple foods per capita in Malawi 1970 – 2007 (MoAFS, 2011).

According to the Ministry of Agriculture, there has not been any policy deliberation on SRI. However, the Ministry was already supporting SRI independently of the introduction under IRLADP, where SRI was only introduced from 2012 at serious scale. The Ministry started supporting a small research program on SRI in the 2009/10 season. Based on the results so far, the technical staff has submitted a proposal to make SRI a formal agronomic practice for upscaling in other regions in the country. A decision will be made shortly on this by the Ministry's Technology Clearing Committee. The requirement for approval is minimum three years of on-station research and two years on-farm trials resulting in superiority compared to old methods.

7.3. INSTITUTIONAL KNOWLEDGE/CAPACITY ON SRI

There is an overall interest within the Ministry to promote SRI, and the staff is generally informed, but the knowledge or capacity is very limited both among the research, extension and farmers. NGOs working with rice do not use the term SRI, but they apply some of the SRI principles wherever feasible as general *good agronomic practices*. NGOs focus on distributing improved seeds from Lifuwu Rice Research Station among farmers and, if needed, advice on cultivation methods, including some elements of SRI.

7.4. PROGRAMME SUPPORT TO SRI

Lifuwu Rice Research Station: The study undertaken by the Lifuwu Rice Research Station is the only scientific study on SRI in the country. It was supported by the Malawian Government and the World Bank. Baka Research Station has also been involved in this study. The trials were first done on-station and subsequently by four lead farmers in each of five districts. The project tested early transplanting, wider spacing, reduced fertilizer application, intermittent irrigation, seed varieties, and application of manure. The combination of methods gave farmers 20-30 % higher yields. Results from the testing showed that (1) transplanting 10-day old seedling gave best results, (2) planting one seedling was better than 4 seedlings per hill, and (3) 20x20 cm spacing gave the best results. Giving half the nitrogen dose and full phosphorus dose was better than normal nitrogen and full phosphorus dose. Seed rate used was only 10 kg/ha and square line planting provided better conditions for growth. There were problems with intermittent irrigation in some of the schemes, mainly due to field conditions and lack of control of water flows, but still, intermittent flooding is recommended at exact periods. A farmer needs to be certain that after draining a field, water will be available again within a few days when the soil starts cracking. Presently, the study is trying to test all the six principles of SRI.

Irrigation, Rural Livelihoods and Agricultural Development program (IRLADP): The project is funded by the World Bank and IFAD and is implemented by the Ministry of Agriculture and Food Security and the Ministry of Irrigation and Water Development from May 2006 to Dec. 2014 (MoAFS and MoIWD). It has focused on constructing and improving irrigation structures for food security and climate adaptation. Four out of fifteen irrigation schemes have been rehabilitated, in addition to the realization of a large number of small-scale irrigation schemes.

However, the irrigation schemes do not work as well as when they were built by the British in the 1960s and 70s due to upstream deforestation and consequent erosion, which resulted in significantly lower flows in the dry season and more intense river flow in the wet season than they were designed for. Irrigation is therefore possible during shorter time periods, or smaller command areas, than before.

The World Bank, Malawi: The World Bank Institute has collaborated with SRI International Network and Resources Center at Cornell University in the US to give training and develop extension materials for the project. The government extension system has taken the training of farmers very seriously. The efforts have had significant impacts so far on farmers' ability to obtain high yields. The project has also arranged study tours for farmers and extension workers to India to study large-scale SRI. Currently, mechanical push weeders are not available at a reasonable cost. Several manufacturers have produced prototypes, but they are expensive for farmers. Local producers need articulated demand and competition to make cheaper and efficient weeders. In the short term, it will be cheaper and safer to import weeders from India, until the technology is locally embedded, and local technicians can repair and reproduce.

The educational system has not yet incorporated SRI in their curricula. Despite the merits of SRI, some of the promoters of SRI might be seen as a bit too "evangelical". SRI combines common sense good agronomy practices into a comprehensive set of interventions, but the package becomes more important to the promoters than the constituent practices. A more down to earth technical look at the pros and cons might be needed with room for local adaptation.

Farmers can easily observe the benefits of SRI and adopt most of its principles. The adoption has, in fact, been easier than for conservation farming, which, at times, seems to be more rigidly imposed on farmers.

The Ministry has made a roadmap for up-scaling SRI in Malawi. More publicity is needed for increased knowledge and dissemination of selected SRI practices to more farmers in a wider area. A field handbook will be prepared to disseminate SRI. The project has best experience with female farmers and female extension workers.

The Smallholder Irrigation and Value Addition Project (SIVAP): is financed under the Global Agriculture and Food Security Program (GAFSP) Multi- Donor Trust Fund. SIVAP is implemented in Karonga, Nkhota-kota, Salima, Machinga and Chikhwawa Districts, within the green belt zone prioritised for agricultural investments. The irrigation schemes will provide water for maize, rice and vegetables. However, the project description does not mention SRI as a potential system for improving rice production.

The African Development Bank: The government focuses on expanding production of maize, cassava and Irish potato in its promotion of food security. Rice and pulses can increase export, generate employment and contribute to food security. Irrigation development can facilitate two crops per year. Currently, much of the irrigation is directed towards sugar cane cultivation. A new large-scale irrigation under the African Development Bank in the Lower Shire is currently being planned. The feasibility study will be finished in 2015 and investments will start in 2016 (AfDBG 2013).

7.5. RESEARCH ON SRI

Previous and ongoing research projects:

The development of SRI practices in Malawi is at infant stage. Some Malawian researchers have experimented with SRI in the past three years and have managed to increase yields by 30 % in the research plots. In Malawi, New Rice for Africa (NERICA) variety has been released in 2011 but promotion is slow among the farming community.

There were a few research projects carried out on rice cultivation practices on different issues by Malawian researchers and students in the agricultural experimental stations that are located across the country. Table 2 presents some of the previous rice research projects in Malawi and main results achieved.

Table 2. Some of the previous research projects on rice cultivation and main results.

Title	**Main results**
Evaluation of cultural practices in the System of Rice Intensification in irrigation schemes by Kanyika, W.A., 2013.	Transplanting a single seedling g at 10 days after seedling emergence, 20 □□20 and applying fertilizers at 40 kg N and 25 kg P_2O_5 per ha was the best combination of cultural practices that farmers can adopt.
Genetic analysis of grain size in F2 populations of crosses between Malawi rice landraces and NERICA varieties by Mzengeza T.R., Tongoona, P., Derera, J., and Kumwenda, A.S., 2010	Two landrace parents, i.e. Faya Mpata and Accession 63 could be potential sources for improvement of grain length and grain shape. Two NERICA varieties NERICA 3 and NERICA 4 could be potential sources for the improvement of grain length.
Response of Nunkile rice variety to fertilizer nitrogen application and plant spacing under irrigated conditions in Malawi by Kanyika, W.A.,; Saka, A.R., and Mviha, P., 2007	The maximum grain yields at Lifuwu was extrapolated to 280 kg/ha of N whereas at Hara, Lifilya and Mkondezi maximum grain yields were attained at 200 kg/ha of N and 160 kg/ha of N at Kasinthula. Farmers should use a plant spacing of 23□15 cm for Senga rice variety.
Evaluating upland rice varieties at Lifuwu rice research station for smallholder cultivation by Mzengeza, T.R., 2007	Among the early duration types, BR 1890-6-1-12, Brown Agora, IET 1444, Vindana, WAB 32-133, WAB 515-B-16A2-10 and WAB99-17 were selected.

Lifuwu Rice Research Station, Salima, has experience in SRI research after managing the World Bank funded SRI project. Staff at Baka Research Station, Karonga, participated in the same project and has gained knowledge and experience. Funding for agricultural research in Malawi has been inconsistent and has declined over time. Better research can boost yields, e.g., through development of improved seeds.

Research capacity on SRI and interest in SRI research: A summary of the main research and extension activities related to rice cultivation carried out by the institutions visited during the mission, is presented in Table 3. There is limited research capacity at Lifuwu Rice Research Station and Baka Research Station. The research capacity on rice at Bunda College is limited to plant breeding. However, existing capacity in agronomy, crop science, soil science and water management can be used for research on rice cultivation.

Table 3. Some of the institutions visited/contacted that have link to rice-related research, developments and extension services.

Institutions	Link to rice cultivation and SRI
Ministry of Agriculture and Food Security, ILADP	• Research on manure in comparison to mineral fertilizers in SRI fields • Training farmers, exchange visits and demand driven extension services • Demonstration of cono-weeders, field days • Developing leaflets and specifications on some of the relevant SRI practices
Bunda College of Agriculture	• The college supplies trained human power in agricultural education like breeders, agronomy but not specifically on rice. In addition, two post graduate students who carried out MSc thesis on rice breeding and adaptation. • Rice as separate course is not given but principles and practices of rice is given for undergraduate students as a chapter.in the general courses • Expose students to research stations to get familiarized with the national rice programme as part of course training.
Lifuwu Rice Research Station	• National rice research centre conducting trials on various agronomic aspects of rice cultivation among others, plant spacing, N application rate, time of planting, testing new varieties, including rice germplasm.

7.6. RECOMMENDATION FOR TECHNICAL SUPPORT/CAPACITY BUILDING ON SRI

Malawi is in an early stage of its rice development efforts, but the interest and commitment by the Ministry for rice in general and for SRI specifically, is relatively high.

Entry points for introducing SRI could be through training of extensions staff, farmers and scientists, inputs and marketing in the four irrigation schemes that have been rehabilitated so far under the Irrigation Rural Agricultural Development Project (IRLADP) supported by the World Bank (2011-2014). Water user associations have been organized in these irrigation schemes, and it would be practical to involve these groups. The area covered by each of the four schemes is approximately 250-500 hectares and manageable in a project mode.

Experience from the IRLADP scheme could be useful, and farmers organized under this scheme can be targeted to take up SRI. Involving Lifuwu Rice Research Station, Salima, and strengthening the demonstration component on farmer field conditions, would be useful as a learning tool to other farmers and also further continue the testing under different local conditions. There are, however, great needs of support for development along the entire rice value chain, including strengthening farmers' organizations/cooperatives on input/output marketing and storage. External support should be open to all needs along the product value chain and to other suitable technical solutions. Some of the challenges are:

- To develop pure seeds and high yielding varieties of rice and make them available to farmers; include aromatic properties into the NERICA variety
- To invest in water control structures – fluctuations in flooding and rainfall are becoming more extreme and difficult for farmers to predict
- There is a need for making organic fertilizers like compost and manure available to rice farmers.
- Start "rice out-growers schemes" in the different provinces, and organize farmer groups linked to commercial agents for input and output
- Demonstrate the benefits of intensification of rice growing in different provinces step by step (pure seeds, introduce row planting, use of low cost and simple tillers and push hoe/weeders,) before introducing the total package of SRI. Provide marketing support, the set price and credit support to farmers by linking the farmer groups with traders

Support can also be given through Lifuwu Rice Research Station, Department of Extension and NGOs that could improve the different aspects in the rice value chain. A broad-based support to rice cultivation (containing elements of SRI), training and marketing in general would appear meaningful.

REFERENCES

AfDBG. 2013. GAFSP: Smallholder Irrigation and Value Addition Project. African Development Bank Group. 28 pp.

Bouman, B.A.M., Lampayan, R.M., Tuong, T.P. 2007. Water Management in Irrigated Rice: Coping with Water Scarcity. International Rice Research Institute, IRRI, os Ban os, Philippines. 54 pp.

Ceesay, M. 2011. An opportunity for increasing factor productivity for rice cultivation in the Gambia through SRI. Paddy Water Environ 9:129-135.

Ceesay M., Reid, W.S., Fernandes, E.C.M. and Uphoff, N.T. 2006.The effects of repeated soil wetting and drying on lowland rice yield with system of rice intensification (SRI) methods International Journal of Agricultural Sustainability
Volume 4, Issue 1. DOI:10.1080/14735903.2006.9686007

Chowdhury, M.R., Kumar, V., and Brahmachari, K. 2012. Effect of different water and nutrient management practices on rice grown under SRI. Journal of Crop and Weed, 8(2): 36-39.

CIIFAD, 2011. The system of rice intensification countries. Cornell International Institute for Food, Agriculture and Development. Ithica. http://sri.ciifad.cornell.edu/countries/index.html.

Dobermann, A. 2004. A critical assessment of the system of rice intensification (SRI). Agricultural Systems 79: 261-281.

FAO. 2010. "Climate-smart" agriculture: Policies, practices and financing for food security, adaptation and mitigation. Rome, Italy.

FAOSTAT. 2014. FAOSTAT (Pilot Version). (http://faostat3.fao.org/faostat-gateway/go/to/download/Q/QC/E (accessed 10 April 2014).

Gathorne-Hardy, A., Reddy, D. N., Venkatanarayana, M. and Harriss-White B. 2013. A life cycle assessment (LCA) of greenhouse gas emissions from SRI and flooded rice production in SE India. Taiwan Water Conservancy Vol. 61, No.4. pp. 110-125

Geethalakshmi, V., Lakshmanan, A., Rajalakshmi, D., Jagannathan, R., Sridhar, G., Ramaraj, A.P., Bhuvaneswari, K., Gurusamy, L., and Anbhazhagan, R. 2011. Climate change impact assessment and adaptation strategies to sustain rice production in Cauvery basin of Tamil Nadu. Current Science Vol. 101, No. 3: 342-347.

GoM. 2012. Malawi Growth and Development Strategy II 2011-2016. Government of Malawi, Lilongwe, Malawi. 183 pp. (http://www.imf.og/external/pubs/ft/scr/2012/cr12222.pdf)

IPCC. 2006. Guidelines for national greenhouse gas inventories, Volume 4. Agriculture, Forestry and Other Land Use, Cambridge, United Kingdom and New York, NY, USA, Cambridge University Press.

Jain, N., Dubey, R., Dubey, D.S., Singh, J., Khanna, M., Pathak, H., and Bhatia, A. 2013. Mitigation of greenhouse gas emission with system of rice intensification in the Indo-Gangetic Plains. Paddy Water Environ. DOI 10.1007/s10333-013-0390-2.

Kanyika, W.A. 2013. Evaluation of cultural practices in the System of Rice Intensification in irrigation schemes.

Kanyika, W.A., Saka, A.R. and Mviha, P. 2007. Response of Nunkile rice variety to fertilizer nitrogen application and plant spacing under irrigated conditions in Malawi, Malawi Journal of Agricultural Sciences 3(1): 70-73.

Katambara, Z, Kahimba, F.C., Mahoo, H. F., Mbungu, W.B., Mhenga, F., Reuben, P., Maugo, M., Nyarubamba, A. 2013. Adopting the system of rice intensification (SRI) in Tanzania: A Review: Agricultural Sciences 4: 369-375.

Krupnik,T. J., Shennan, C., and Rodenburg, J. 2012. Yield, water productivity and nutrient balances under the System of Rice Intensification and Recommended Management Practices in the Sahel. Field Crops Research 130: 155–167.

LCBCCAP. 2012. A rice value chain analysis in Lake Chilwa Basin under LCBCCAP and WALA Projects. Lake Chilwa Basin Climate Change Adaptation Programme (LCBCCAP). 21 pp.

McDonald, A.J., Hobbs, P.R., and Riha, S.J. 2006. Does the system of rice intensification outperform conventional best management? A synopsis of the empirical record. Field Crop Research 96: 31-36.

McDonald, A.J., Hobbs, P.R., Riha, S.J. 2008. Stubborn facts: still no evidence that the system of rice intensification out-yields best management practices (BMPs) beyond Madagascar. Field Crop Research 108: 188-191.

MoAFS. 2011. Malawi Agricultural Sector Wide Approach A prioritised and harmonised Agricultural Development Agenda: 2011-2015. Ministry of Agriculture and Food Security. Lilongwe, Malawi. 181 pp.

MoAL. 2013. Zambia – National Agriculture Investment Plan (NAIP) 2014-2018: Under the Comprehensive Africa Agriculture Development Programme (CAADP), Final Draft. Ministry of Agriculture and Livestock, Lusaka, Zambia. 102 pp.

Mzengeza, T.R. 2007. Evaluating upland rice varieties at Lifuwu rice research station for smallholder cultivation. Malawi Journal of Agricultural Sciences 3(1): 58-69.

Mzengeza, T.R., Tongoona, P., Derera, J. and Kumwenda, A.S. 2010. Genetic analysis of grain size in F2 populations of crosses between Malawi rice landraces and NERICA varieties, Innovation and Partnerships to Realize Africa's Rice Potential: paper presented at Second Africa Rice Congress, Bamako, Mali, 22– 26 March 2010.

Ndiiri, J.A., Mati, B.M., Home, P.G., Odongo, B., and Uphoff, N. 2013. Adoption, constraints and economic returns of paddy rice intensification in Mwea, Kenya. Agricultural Water Management 129: 44-55.

ORIZA. 2014 http://oryza.com/news/rice-news/tanzania-promotes-commercial-farming-irrigation-schemes-boost-rice-production#sthash.l8fwWAax.dpuf

Palanisami, K., C.R.Ranganathan, K.R.kakumanu and Udaya N. Sekhar. 2011. A hybrid model to quantify the impact of climate change on agriculture in Godavari Basin, India, Energy and Environmental Research, Vol. 1(1).

Rajkshore, S.K., Doraisamy, P., Subramanian, K.S., and Maheswari, M. 2013. Methane emission patterns and their associated soil microflora with SRI and conventional systems of rice cultivation in Tamil Nadu, India. Taiwan Water Conservancy Vol. 61, No.4, pp. 126-134.

Rao, A.U., Rajendra, P., Rao, R.S.N., Vijay, D., and Sridhar, T.V. 2013. Evaluation of system of rice intensification (SRI) on alluvial soils of Andhra Pradesh, J. Soils and Crops 23 (1) 36-40.

Reddy, V.R., Reddy, P.P., Reddy, M.S., and Raju, D.S.R. 2005. Water use efficiency: a study of system of rice intensification (SRI) adoption in Andhra Pradesh. Indian Journal of Agricultural Economics 60: 458-472.

Sharma, C., Tiwari, M.K., Pathak, H. 2008. Estimates of emission and deposition of reactive nitrogenous species in India. Curr. Sci. 94 (II): 1439-1445.

Siopongco, J.D.L.C., Wassmann, R., and Sander, B.O. 2013. Alternate wetting and drying in Philippine rice production: feasibility study for a Clean

Development Mechanism, Technical Bulletin, No.17, International Rice Research Institute, 14 p.

Stoop, W., Uphoff, N. and Kassam, A. 2002. A review of agricultural research issues raised by the System of Rice Intensification (SRI) from Madagascar: Opportunities for improving farming systems for resource-poor farmers, Agricultural Systems 71: 249-274.

Thiyagarajan, T.M. & Biksham, G. 2013. Transforming rice production with SRI (System of Rice Intensification) knowledge and practice. National Consortium on SRI (NCS), 206 pp.

Uphoff, N. 2007. Reducing the vulnerability of rural households through agroecological practice: Considering the System of Rice Intensification (SRI), Mondes en Developement, 35:4.

Uphoff, N., Kassam A., Stoop, W. 2008. A critical assessment of a desk study comparing crop production systems: The example of the 'system of rice intensification' versus 'best management practice' by Field Crops Research 108: 109-114.

Uphoff, N., Kassam, A., Hardwood, R. 2010. SRI as a methodology for raising crop and water productivity: productive adaptations in rice agronomy and irrigation water management. Paddy Water Environ. 9, 3–11USAID, 2013. Congressional budget justification FY 2004: Sub Saharan Africa. http://www.usaid.gov/policy/budget/cbj2004/sub-saharan_africa/

Uprety D.C., Dhar S, Hongmin D, Kimball BA, Garg A, Upadhyay J. 2012. Technologies for climate change mitigation: agriculture sector. Department of Management Engineering, Technical University of Denmark.

V&A programme. 2009. Vulnerability and adaptation experiences from Rajasthan and Andhra Pradesh. The System of Rice Cultivation, SDC V&A programme, India.approach to river basin management. Earthscan, 166 p.

Veeraputhiran, R., Balasubramanian, R., Pandian, B.J., Chelladural, M., Tamilselvi, R., Renganathan, V.G., 2012. Influence of system of rice intensification on yield, water use and economics through farmers' participatory approach. Madras Agric. J. 99 (4-6): 251-254.

Zheng-Qin, X., Guang-Xi, X., and Zhao-Liang, ZHU, 2007. Nitrous oxide and methane emission as affected by water, soil and nitrogen. Pedosphere 17(2): 146-155.

ANNEX 1. LIST OF ORGANIZATIONS AND PEOPLE CONSULTED IN TANZANIA

Agicultural Council of Tanzania/Tanzania Agricultural Partnership Program	Mark J.Magila, National Coordinator Susan M.Masagasi; Field Operations Manager	25.03.14 Dar-es-Salaam
SAGCOT secretariat	Geoffrey Kirenga	25.03.14 Dar-es-Salaam
Sokoine Agricultural University Department of Agricultural Engineering Department of Crop Science and Production Department of Research and Development, Dakawa Research Institute, Min of Agriculture and FS,	Dr. Henry Mahoo, Dr-Ashura Luzi-Kihupi Hezron K.Tusekelege Prof Rwehumbiza	26.03 Morogoro Morogoro Morogoro
Africa Rice	K. Senthilkumar	27/3 Dar-es-Salaam
Chollima Research Institute	Joel Zakayo	26.03 Dakawa
Kilombero Plantations Plantations (KPL)	Carter Coleman	27.03Dar-es-Salaam
NAFAKA	Lee Rossner	27.03
Ministry of Agriculture, Food Security and Cooperatives (MAFC) Ministerial Delivery Unit (MDU-MAFC) for BRN	Dr. Hussein Mansoor (Directorate of Crops) A. Henri Urio (BRN) henriurio@gmail.com	25.03.14 Dar-es-Salaam

ANNEX 2. LIST OF ORGANIZATIONS AND PEOPLE CONSULTED IN ZAMBIA

Organizations	*Names and positions*
Ministry of Agriculture, Zambia Agriculture Research Institute, ZARI: Permanent staff	Moses Mwale, Director Monde Siyandwa Zulu, Deputy Director Samuel Phiri, Deputy Director Mukanga Mweshi, Chief Agriculture Research Officer Dickson Ng'oni, Chief Agriculture Research Officer Milimo Chiboda Sakala, Programmes Office Ivor Mukuka, Chief Agriculture Officer
Ministry of Agriculture, Zambia Agriculture Research Institute in cooperation with JICA: Food Crop Diversification Support project Focusing on Rice Production (FoDiS-R)	Kasuya Masahiro, Rice Cultivaton System Specialist, JICA Mathias Ndhlovu, Economist, JICA Tokutaro Iino, Project Coordinator, JICA Jiro Nozaka, Agriculture and Rural Development Advisor, JICA Ireen Ngulube, Zambian Counterpart, ZARI
Ministry of Agriculture, ZARI, Misamfu Regional Research Station, Rice Research Department	Musik Chitambi, Research Scientist (telephone interview)
Univeristy of Zambia, UNZA	Kalaluka Munyinda, Professor, Crop Science Dept. Elijah Phiri, Associate Professor, Soil Science Dept.
COMESA/CAADP	Mbosonge Mwenechanya, Country Process Facilitator – IPPSD/CAADP
COMACO	Dale Lewis, President and Director of Conservation Agriculture Richard Mumba, Project Manager Erika Styger, Cornell University
CONCERN	Carl Wahl, Conservation Agriculture Coordinator, Mongu Office
Conservation Farming Unit (CFU)	Peter Aagaard, Director Collins Nkatiko, Director
Programme Against Malnutrition, PAM	Henry Nyondo, Project Coordinator

ANNEX 3. LIST OF ORGANIZATIONS AND PEOPLE CONSULTED IN MALAWI

Organizations	*Names and position*
World Bank, Lilongwe	Pieter Waalewijn, Sr. Irrigation and Water Resources Specialist
African Development Bank	Andrew Mwaba, Resident Representative Frank Boahene, Human Development
Ministry of Agriculture and Food Security, Irrigation, Rural Livelihoods and Agricultural Development Project (IRLADP)	Rexy J.S. Tolani, Social and Business Development Specialist W.A. Kanyika, Station Manager, Baka Research Station John Hennock, Crops Officer, Crops Department Tenyson Mzengeza, Deputy Director and Rice Breeder Henry Msatilomo, Chief Agricultural Extension Officer, Dept. of Agric. Extension Pearson Soko, Assistant Chief Agribusiness Officer, Dept. of Agric. Extension Godfrey Liwewe, Senior Agrobusiness Officer, Dept. of Agric. Extension Wisdom Nzima, Senior Agrobusiness Officer, Dept. of Agric. Extension Andrew Chamanza, Senior Agrobusiness Officer, Dept. of Agric. Extension
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ISSN: 1892-8102

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