Rice production diagnostic for Chinsali (Chinsali District, Northern Province) and Mfuwe (Mwambe District, Eastern Province), Zambia

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For COMACO and
David R. Atkinson Center for Sustainable Development

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1. Introduction

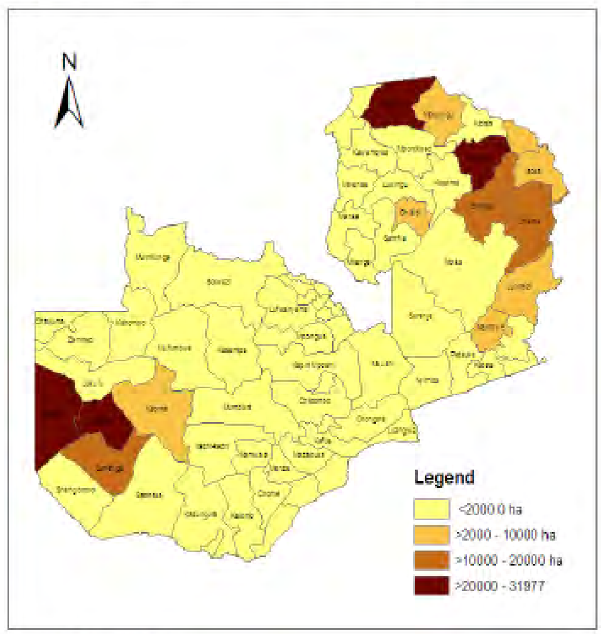
The Zambian Ministry of Agriculture and Livestock has designated rice as one of the strategic food crops for Zambia, in addition to maize, cassava, sorghum, millet, sweet and Irish potato, and wheat. Rice is also recognized as having the potential to significantly increase incomes and employment among rural producers. One of the main government strategies for the agricultural sector is to diversify the range of competitive crops other than maize by focusing on increasing productivity and value addition of the selected crops (Republic of Zambia, 2011 and 2014).

Among all staple food crops in Zambia, rice is the only one in deficit, and the deficit increases every year. Although rice production in Zambia has tripled since early 2000 from about 17,000 MT/year to an estimated 47,000 and 54,000 MT/year in 2010 and 2013, respectively, rice consumption for the latter period was between 62,500 MT and 66,500 MT, creating an estimated annual rice deficit of 12,500-15,000 MT. Indeed, per capita consumption of rice increased from 1.49Kg in 2002 to 4.9Kg in 2013. Zambia's 64,500 rice farmers each produce on average less than 1 MT of rice/year (Republic of Zambia, 2011 and 2014).

Rice is mostly grown in the Northern and Eastern Provinces, which overlaps with COMACO's intervention zone (see map next page), and in the Western Province around Mongu. Because these rice-growing regions are quite isolated from the major urban markets, it is a challenge to profitably produce and market rice in Zambia (Sitko et al, 2011).

Nevertheless, potential to increase rice production is high. Large areas of land suitable to rice production are available and there is a high consumer demand for local rice. Zambians favor the local varieties from Mongu, Nakonde and Chama over imported rices due to the aroma, cooking quality and white color of the local rices.

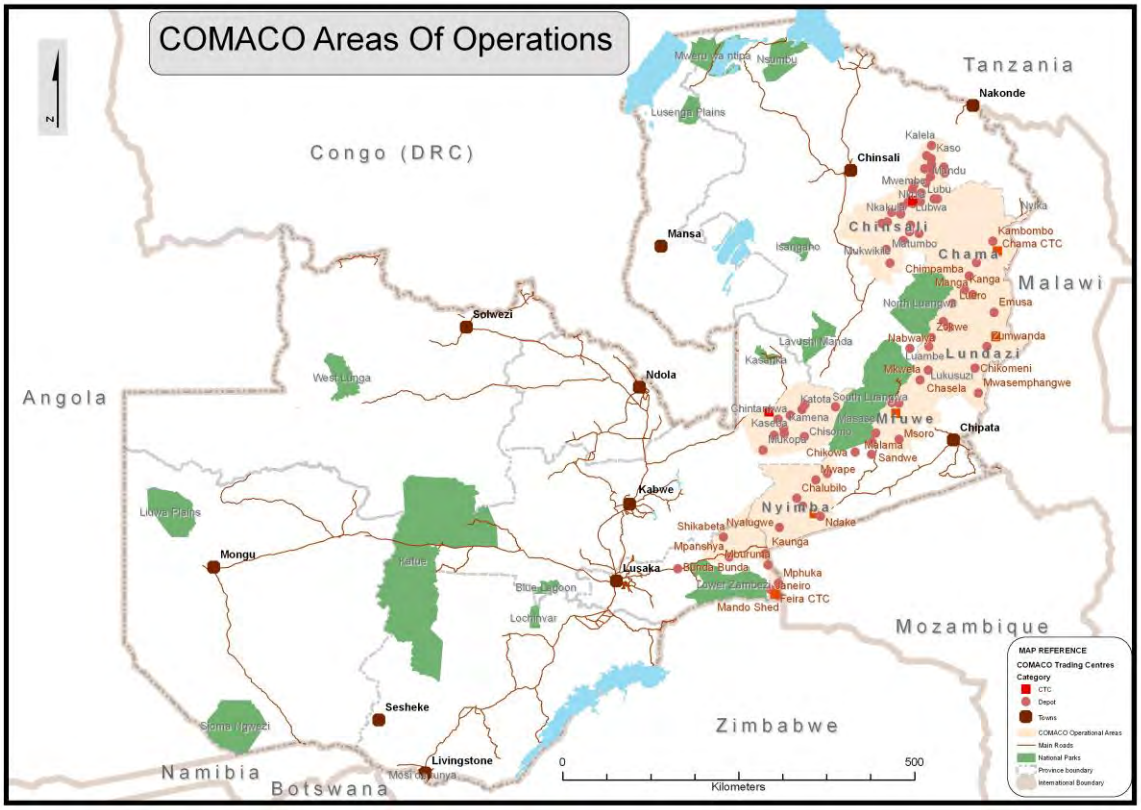
Map 28. Rice Production – Hectares 2009/10



Source: CFS 2009/10

(Cited by Sitko et al, 2011)

Community **Ma**rkets for **Co**nservation (**COMACO**) is a limited-by-guarantee, non-profit company doing business as COMACO Ltd. COMACO's vision is to secure the Luangwa Valley ecosystem from human disturbance by creating livable incomes and food security for the population living in proximity to the Southern and Northern Luangwa, Luambe, Lukusuzi, and Lower Zambezi National Parks and the surrounding natural areas. Through trade incentives and markets, farmers are given the opportunity to produce and sell organic products, while protecting and managing the associated natural resources and landscapes sustainably.



The company is primarily a food-processing business that markets organic, healthy, nutritious value-added products derived from commodities grown by farmers i) who live in proximity to protected wildlife and forest areas and ii) who are members of COMACO producer groups. Products marketed under the **IT'S WILD!** brand to Zambia's urban consumers include, among others, Chama rice, peanut butter, Yummy Soy, groundnuts and honey.

This innovative model has proven to be very successful. In 2013, COMACO worked across the Luangwa valley in 54 chiefdoms, with more then 80,000 farmer-members organized into 3,939 producer groups. COMACO's year-round field support to farmer-members is provided by 1,139 lead farmers, 28 senior lead farmers and 40 area managers (COMACO, 2014).

Rice has become COMACO's most important product. During the 2012 season, rice made up 43.1% of COMACO sales, followed by peanut butter at 27.8%. Market share for other products was much smaller: honey at 7.9%, and less than 2% each for all other products such as beans, dried mangoes, and wild mushrooms (COMACO, 2012).

Following a thorough selection process of the regional rice varieties, COMACO identified a local variety from the Chama District to be the most attractive variety for the local market, now produced and marketed under the name "Chama rice". Chama rice is exceptionally rich-tasting, with a distinct aromatic flavor, and a grain that is clear white with a rounded oblong shape. These qualities, together with its non-sticky cooking properties, have made Chama rice very popular with Zambian consumers. IT'S WILD! Chama rice is sold as white rice or brown rice in 1kg, 2kg, 5kg and 25kg packages. COMACO also markets a slightly inferior quality rice from Chinsali at a lower price under the "Nakonde" label (COMACO, 2013).

Since 2004, COMACO works with farmers on improved rice farming techniques, such as line planting. In 2009, Henry Ngimbu, a specialist consultant, was hired to train COMACO staff and farmers in Chinsali and Mfuwe on the use of the System of Rice Intensification (SRI) methodology[1]. However, since 2010 little systematic and technical follow-up on the rice production system has been possible, and thus COMACO had little insight into how farmers grew rice or what constraints they faced.

While sales of Chama rice were increasing, two major problems started to emerge:

1. Quality decreased of Chama rice grown in Chinsali in the Northern Province. Because Chinsali has increased its Chama rice production over the past 3 years and now produces most of COMACO's rice, this problem urgently needs to be addressed.
2. Weather-related harvest losses, due to either extended dry spells during the rainy season or flood events have become significant over the past two to three years. Finding strategies to adapt to highly variable weather is critical not only for the farmers but also for COMACO's future business.

Because these two factors threaten expansion of the rice available for its markets, COMACO management commissioned this rice diagnostic to more closely examine how to address these two constraints and more generally look into the potential for improving rice production and the use for SRI. This diagnostic should also provide recommendations for the start-up of the 5-year rice project (starting in June 2014 and supported by the Royal Embassy of Norway in Zambia), to offer targeted technical support to Chama rice farmers, in order to achieve high yields and better quality.

This report is based on findings from a two-week field trip to Chinsali and Mwambwe district (Mfuwe) from April 16 to April 30 (see Annex 1 for the Program). The team included COMACO staff Richard Mumba, Emmanuel Kashinge and Maxwell Muunga for the Chinsali area; and Jonathan Mulambya, Luke Lungu, Moses Njobvu, and Major Lungu for the Mfuwe area, in addition to Henry Ngimbu and myself. Findings are a result of extensive conversations with COMACO field staff, informative field visits, and in-depth discussions with farmers. Support for this diagnostic was provided by COMACO (http://www.itswild.org/), the Royal Embassy of Norway in Zambia (http://www.norway.org.zm/), and by the David R. Atkinson Center for a Sustainable Future at Cornell University (http://www.acsf.cornell.edu/).

1 *SRI was introduced to Zambia by Henry Ngimbu in 2005, who trained farmers in North Western and Zambezi province. For more information on SRI in Zambia, visit http://sri.ciifad.cornell.edu/countries/zambia/index.html*

Main objective

Identify potentials for improving Chama rice productivity and quality, including the opportunity to use the System of Rice Intensification (SRI) in the COMACO project zones of Chinsali and Mfuwe, Zambia.

Specific objectives

- Identify current crop production practices, if and how the SRI methodology is applied
- Determine rice yields for Chama rice
- Identify why the aroma of Chama rice is not sustained in the Chinsali region. Identify quality management issues in Mfuwe.
- Identify practical strategies for stabilizing rice production while facing climate variability.
- Recommend how to improve rice productivity and rice quality, and how to better integrate SRI in the COMACO intervention zone
- Advise in the planning and start- up of the new COMACO rice project.

2. Rice systems in Zambia and COMACO rice production zones

In Zambia, almost all rice is grown in rainfed lowland systems, as very few irrigation schemes exist and rice is not grown in the uplands (see definitions of rice systems in text box below).

Rice is present in most areas of COMACO's intervention zone. The two main zones can be characterized as **Northern Floodplain Rice Production zone** and the **Eastern Dambo Rice Production Zone**. In the Chinsali District in the North, rice production is associated with the floodplain of the large Chambeshi River, and with dambos (a lowland system widespread in southern Africa, see definition in text box below). In the Eastern Project Zone, most rice is grown in dambos. A list of all the rice-growing sites in the COMACO intervention zone was not available. The following information might therefore not be entirely accurate.

Sites visited during this diagnostic are indicated in **bold**.

i. **Northern Province: Northern Floodplain Rice Production zone**
   - **Chinsali District**
   - <u>Kaso</u> with ***Mbesuma, Chembe Malata***, *Kambwi, Mulenga Adam, Kalela, Chunga, Bwinambo, Kalasa, Shimuinda, Nantete, Kakongola*
   - <u>Central</u> *with Mulolo,* ***Cheswa, Chintankwa, Kawama***
   - <u>Ilondale</u> *with Bubende, Lumpene*

ii. **Eastern Province: Eastern Dambo Rice production zone**
   - **Mambwe: Mfuwe with *Mnkhanya, Kakumbi, Nsefu, Mwanya,***
   - Lundazi: sites to be identified
   - Chama: sites to be identified
   - Nyimba: sites to be identified

Five field sites were visited during this diagnostic, located in the floodplains (Cheswa, Betsuma, Chembe Malata) and in dambo depressions (Kawama, Chintankwa). In Mfuwe, all sites were situated in dambos.

Definition of rice systems

Irrigated systems are differentiated from rainfed systems. Rainfed systems include rainfed upland and rainfed lowland systems.

- An irrigated system is a system where irrigation water is added to a rice field in addition to rain (during the rainy season) or is essential for growing a crop (during the dry season). Fields may be flooded at least part of the time, and the level of flooding can be controlled.
- In a rainfed upland system, rainfall is the only source of water and soils drain freely. Soils are aerobic. Fields do not experience flooded conditions.
- A rainfed lowland system is flooded non-continuously at variable depth and duration, often during the second half of the growing season. Soil conditions vary between aerobic and anaerobic. Flooding occurs from rainfall, from runoff of above-stream locations, rising groundwater tables or from rising levels of bodies of water such as rivers or lakes.

Definition of dambo

A dambo is a lowland system widespread in Southern African sub-region. Dambos are drainage depressions subject to excessive wetness/flooding in varying proportions for different lengths of the time during the year. Surface runoff and seepage of groundwater from catchment areas over an impermeable substratum towards lower lying areas, together with incident precipitation, contribute to the water budget of dambos (Mharapara, 1994). Water enters the dambo mostly through rainfall and through water migrating below the soil surface, and less through surface water run-off. High groundwater tables can surface and flood an area. Water leaves the dambo through evapotranspiration and streamflow. Dambos are very diverse and can have different characteristics (Mharapara, 1994).

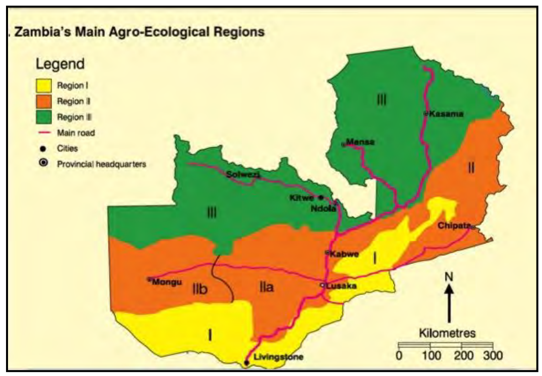
The floodplains and the dambo system both qualify as lowland systems, as flooding occurs at some point during the rainy season. Rice is the only crop that tolerates flooding, and the only crop that is planted during the rainy season in the lowlands. All other crops (maize, groundnuts, cassava) are grown in the uplands. Upland crops do not tolerate prolonged flooding periods. Maize, for instance, dies back after five days of flooding. This marks therefore a spatial separation of the rice crop from all other crops. In the North as well as in the East, there are large areas of unused lowlands. Rice can be grown on that land without competing with upland crops.

Thus, rice production is complementary to other agricultural activities, contributes to diversification of production, and diminishes the risk of exclusive dependence on rainfall for agricultural production. High groundwater tables and flooding can occur locally, even if rainfall is lacking. To cite one example from the Mfuwe area: the lowlands there can be flooded based on heavy rains in the plateau area of Chipata, even if there has been no rain in Mfuwe.

Interestingly, some (e.g. the Zambia National Rice Development Strategy; Republic of Zambia, 2011 and 2014) have put forth the notion that rice is and should be grown in the uplands in Zambia. We argue that this is actually not the case (based on the definitions given above) and cannot be recommended. Rice would directly compete with the other upland crops, and would be vulnerable to droughts. During the rainy season, the spatial separation of crops makes perfect sense, because rice can use the lowlands as no other crop can, and can take advantage of water in higher abundance.

3. Northern Floodplain Rice Production zone, Chinsali District, Northern Province

3.1. Agricultural system overview



The Northern Province is situated in the agro-ecological Region 3 characterized by rainfall of 1,000-1,500 mm/year. Soils are loamy, leached, acidic, low in organic matter and not very fertile. These factors, combined with difficult market access, limits the variety of crops cultivated. Nevertheless, large water resources provide a good potential for intensification of various crops, if soil fertility is well managed. (IMWI, 2009; Republic of Zambia 2011). The rainy season runs from November to April, covering a six-month period, with heaviest rains occurring in December, January and February (see also Annex 2).

Main agriculture upland crops are maize, manioc, sweet potato, groundnuts, different types and varieties of beans, soybeans, and millet. Important vegetable crops include kale, cabbage, rape, tomato, and onion. Cassava leaves, bean leaves, pumpkin leaves, and sweet potato leaves are consumed as leafy vegetables. All these crops grow on the uplands during the rainy season, and vegetable cropping is extended into the dry season in dambos, in locations where irrigation water is available. All maize is planted with government-subsidized fertilizers (this differs with the Mfuwe area). Thus, the area planted with maize corresponds directly to the amount of chemical fertilizer available to farmers. Soil fertility degradation issues are important on the uplands. Conservation agriculture practices, which are spreading in the North, focus on maize, soybeans and groundnuts, but are not yet applied to the rice crop. Livestock is mostly absent, as people have traditionally not kept livestock.

3.2. Rice production practices

Rice systems in Chinsali are managed very extensively. Before the arrival of COMACO, farmers planted only small areas of rice, mostly for home consumption. Since COMACO has been providing a secure market, farmers have rapidly expanded the area under rice cultivation.

The Northern Zone has become the main rice supplier for COMACO. In 2012, 1050 tons were produced in the North and 750 tons in the East. COMACO's rice purchase volume has increased rapidly in the Northern Zone over the past four years from 50 tons in 2010/2011, to 250 tons in 2011/2012, and to 1050 tons (2012/2013). COMACO plans to buy 1100 tons during this current 2013/2014 season, the maximum given the local milling capacity. Plans underway to expand rice-milling capacity will allow increased production volume from the North. About 2000 farmers are members of the local rice farmer associations, and roughly half of them sell their rice to COMACO.

Rice is grown both in the floodplain of the Chambeshi River and in dambos, which are located higher up on the slope from the floodplain (see description of system in previous section). Not all villages have access to both zones, but where they do, farmers plant rice in two to three locations. The rice fields can be fairly distant from the homestead and the upland (non-rice) fields, and can also be far apart from each other.

Soil preparation: Land is prepared by family members using hand hoes over a period of several months during the dry season. Some farmers begin preparing the land as early as June, immediately after the rice harvest, when water has receded and soils are still humid. Others wait until September or October. After hand plowing, soil chunks are broken up and the seedbed is prepared in October and November. The soil preparation for rice does not compete with other agricultural activities, as soils remain humid throughout the dry season. In contrast, upland soils dry out and turn hard during the dry season. Soil preparation can start only after the first rains, which soften the hardened soils.

Crop establishment and management: Following the first rains in November/December, farmers seed rice by broadcasting, using about 80-100 kg/ha, according to farmers interviewed in Chembe Malata. Farmers plant Chama rice and/or 'Super Rice', which is a mixture of local varieties. Weeding is done only occasionally or not at all. Fields are naturally flooded during the second half of the cropping cycle. The timing and depth of flooding varies with each rainy season. Soils are not fertilized. There are no insect or fungal diseases associated with Chama rice. Birds and rodents can be a problem at the time of seeding and harvest.

Yields: Both Chama and Super Rice yields remain low at 1 t/ha or less. Farmers who plant in line and weed their fields can attain 2.5 t/ha. Using SRI (see below), yields reached 3 - 3.2t/ha.

As land availability is not an issue, size of rice plots depends on how much land a farmer is able to plow by hand, on availability of seed, and whether the rains or floods arrive earlier or later in the season. Area under rice per household ranges from ¼ ha to 4 ha in Cheswa village (averaging 2 hectares), averages about 2.5 ha in Chembe Malat village, and can reach 10 to 20 ha in Kawama village, as indicated by lead farmer Wilson. The better-off farmers, who can afford to hire labor, plant the larger rice fields.

Climate dependency: Rice production is highly dependent upon rainfall distribution and the timing and level of flooding during the rainy season. Floodplains are prone to flooding and dambos are vulnerable to drought. Farmers who planted rice in dambos (located higher up the slopes) lost their rice crop due to dry weather in each of the past two years. As a result, farmers planted their rice crop to the floodplain in the current year. Unfortunately, because this has been a very wet year, the early and deep flooding reduced the rice production in the floodplain. Conditions in the dambos would have been better.

Timing of planting makes a big difference in crop productivity. Planting from mid-November to mid-December allows the crop to develop more vigorously and tiller much better. Planting in January means rice plants will be flooded during the vegetative phase, slowing plant development and resulting in significantly reduced yields.

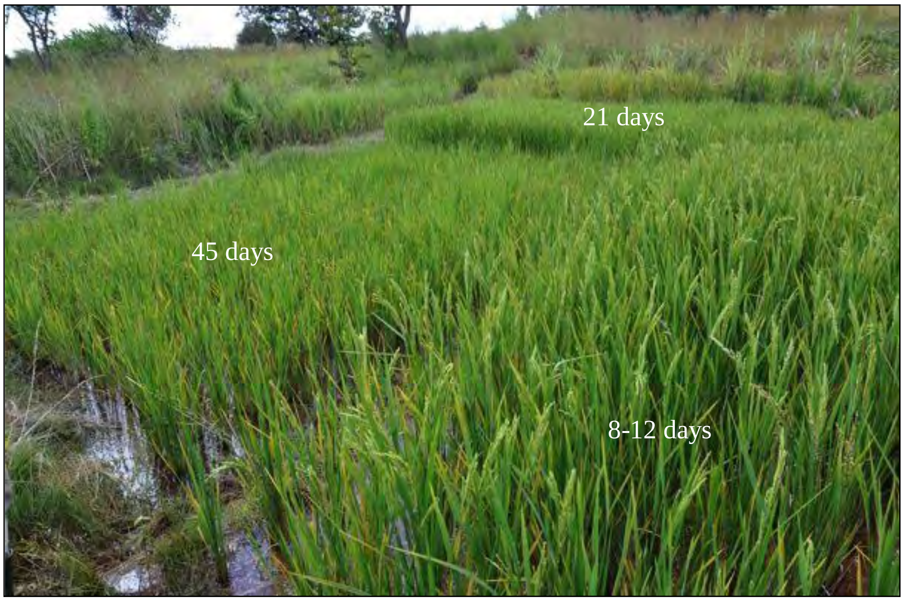
Under this very extensive crop management approach, some farmers “abandon” their crop after planting and return only for harvest. Rice thus becomes a purely speculative crop, with no guarantee of harvest or profit, despite the time and resources invested to plant the fields.

Rice is a “new” cash crop in the area--especially as COMACO is offering a market for Chama rice-- and farmers indicate significant interest in further expansion. But there are currently many uncertainties and constraints for farmers to be able to gain much benefit from rice production.

3.3. The application and performance of the System of Rice Intensification in Chinsali

Henry Ngimbu trained Chinsali rice farmers in SRI for COMACO in 2010. The same year, COMACO supplied 20 tons of Chama rice seed to farmers to enable them to produce this more expensive rice and sell it to COMACO at a higher price than the “Super Rice” they had grown previously. Although there was no systematic follow-up or technical monitoring after the SRI trainings, we found SRI plots dispersed within the larger rice area at all of the sites visited.

During the 2013/2014 season, lead farmers installed 10 demonstration plots throughout the COMACO zone, comparing traditional methods to SRI methods. We visited three demonstration sites: Kawama, Cheswa and Chintakwa. The plots were very well set up and managed: treatments were implemented at the same time, with the same seed, planted side-by-side, thus making a good comparison possible. In fact, we were highly impressed by their quality. These plots could have provided very good data, but unfortunately there was no provision made for data collection.



Kawama demonstration plot shows how seedling age at transplanting influences crop development

Demonstration plot in Kawama with **SRI no weeding (left) compared to SRI with 3 times weeding (right)**; using the same seed, same date of planting, same fertilization. SRI with 3x weeding produces a healthy green crop, whereas with no weeding crop development is slowed, plants are yellowish and suffer from weed competition,

Apart from the demonstration plots, lead farmers and other farmers have put small SRI plots in place as part of their larger rice fields. The SRI plots were scattered throughout the rice production area. It was obvious that SRI plots significantly outperformed the conventional plots. Farmers in Betsuma reported yields with Chama rice of 3.2 t/ha using SRI, while yields for conventionally grown rice were between 1.3-1.8t/ha. In Chembe Malata, SRI yields reach 3t/ha. Both sites are located in the Chambeshi floodplain. Although farmers recognize the benefits of SRI and witness a doubling or tripling of production, little larger-scale uptake of SRI was found. The question is why? What are the constraints?

SRI plot transplanted at 12 days, 25cm x 25cm spacing, 1 seedling, 1x weeding with handhoe

Comparison of SRI and conventional method managed by lead farmer (middle)

Seeds were broadcast, 1x weeding by hand

Side-by-side comparison, two plots (20mx15m each), both plots were fertilized with Jatropha cake; plots were started at the same day (nursery seeding for SRI and broadcasting seed in conventional plot). Difference in development is obvious: SRI plants are greener, taller, tillers are thicker; plants are more vigorous, panicle development ahead of conventional plot.

3.4. Challenges and constraints to rice intensification

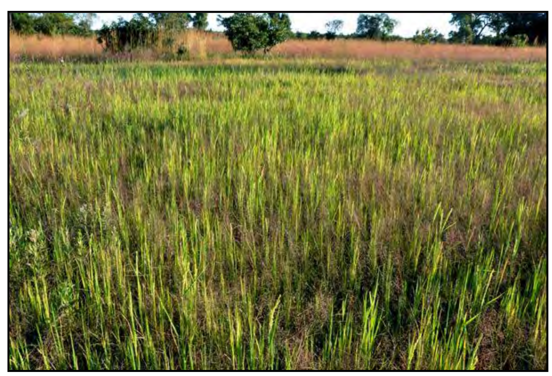
- **Rice production strategies are currently based on extensification and not on intensification**. Increasing production is done by expanding the area under cultivation without improving the underlying agricultural practices. Farmers have large rice fields in several locations. One is considered a “successful” rice farmer for having a large area of rice under cultivation rather than for attaining high yields. Even if SRI plots show much better performance throughout the COMACO zone, it has been difficult for farmers to switch to SRI, especially for those who plant two or three large rice fields distant from one another. Farmers focus on their upland food crops during the rainy season, and are not able to closely monitor and manage their rice fields. For farmers, SRI plots are still considered “test” plots integrated into their larger fields. Time constraints make it difficult for farmers to provide extra care for their small SRI plots, which explains why some of the SRI plots were better managed than others. On the positive side, the presence of SRI plots makes it obvious that farmers are interested in it.

SRI farmer plots in the floodplain of Cheswa. The majority of rice was broadcast, but some fields were planted late with SRI. On the left without weeding, on right with weeding.

- **Variable rainfall and flooding patterns** discourage farmers from moving towards intensification. Farmers never know exactly when and how quickly the rains and flooding will arrive or how deep the flooding will be. Droughts or floods may damage their rice crop. These conditions make rice a "speculation" crop.
    - ➢ Any intensification effort would need to include improved water management to buffer against irregular rainfall, dry spells and flooding.

- **Crop and weed management is neglected,** as it is time-consuming and tiresome for farmers to move between their several plots dispersed in different zones. Also, rice is a cash crop, but farmers' main focus is on their uplands food crops such as maize, cassava, sweet potato, beans and groundnuts. Weeding rice fields is simply not a priority and is thus often neglected. Because fields are not weeded, weed species are able to disperse their seeds, further infesting the rice fields, and building up of the weed seed bank and associated weed pressure. This might also explain that the weed problem varied from site to site. Some were relatively weed-free, while others showed heavy weed infestation.

- **Soil fertility management is poor, and soils degrade quickly, especially in dambos.** Farmers in Chintankwa planted rice in the same dambo for five consecutive years. The rice crop looked very poor and yields will be very low. Farmers will soon have to let plots return to natural fallow to restore fertility. When soils become so heavily degraded, it takes a very long time to restore soil fertility. This is not sustainable in the long run, as farmers might want to return to cultivating the land prematurely. It is also doubtful that farmers will make any profit from the plots that have been cultivated consecutively for five years, considering the very low yields in relation to the cost of seed, land preparation and harvest.
    - ➢ Intensification efforts should include improved soil fertility restoration and management. Soils should not be allowed to become heavily depleted.

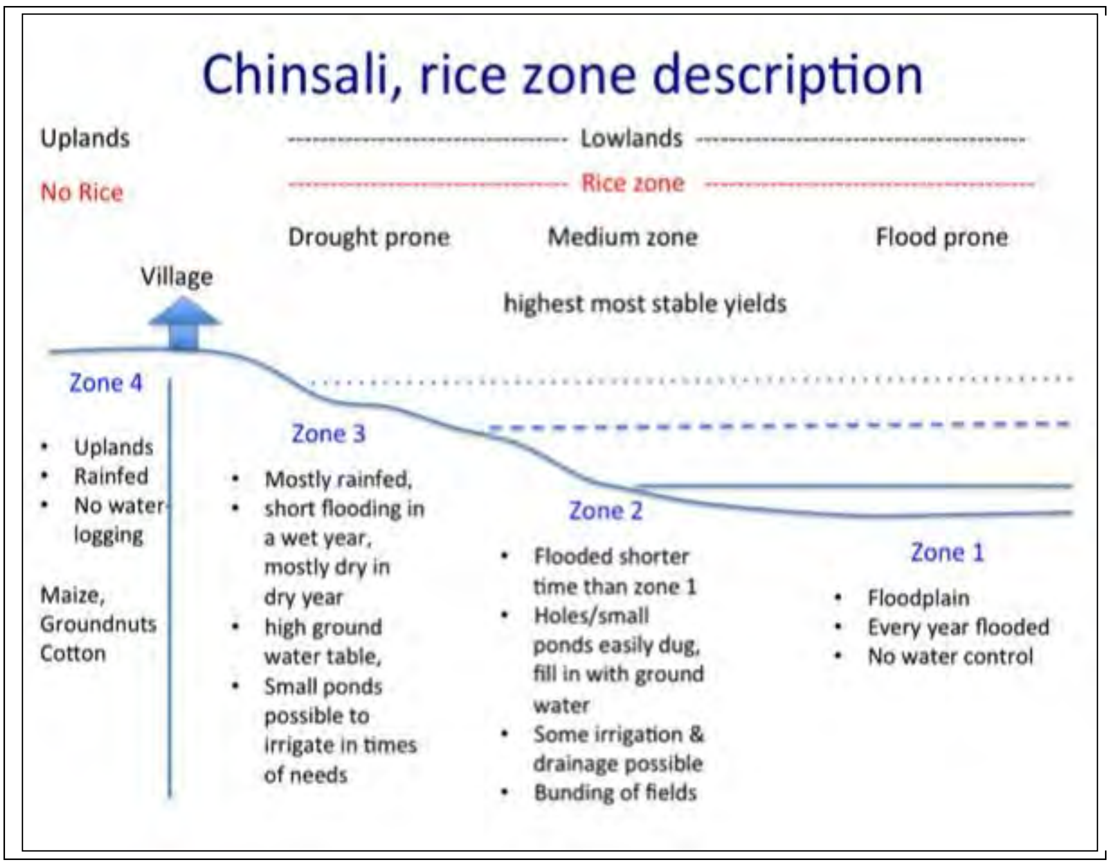
Chintakwa: Zone 3, dambo soils here are highly degraded. Although SRI plots were not as vigorous as in the flood plain and on better dambo soils, the SRI plot (left) looked much better compared to traditional plot (right)

- **Labor allocation:** Farmers hesitate to allocate labor for crop establishment and more intensive management practices, such as weeding, as they are already fully occupied with their upland crops. Also, allocating additional labor to rice under this extensive system gives only a minimal return.
    - Any approach to sustainable intensification must find ways to get a higher and obviously beneficial return using available labor.

3.5. Description of three lowland rice production zones in Chinsali

Given the difficulties inherent in changing from an extensive to intensive cropping system, we need to look more closely at the different rice-growing environments. This is especially important to identify strategies for adapting to climate variability.

We identified three distinct rice-growing zones where COMACO operates in Chinsali, represented in the following figure:



<u>Zone 1: Chambeshi floodplain:</u> This zone is flooded during 1-3 months (February through April) every year. The extent and duration of the flooding depends on the water level of the Chambeshi, one of Zambia's large rivers. No water control or regulation is possible. This year flooding came earlier and was much higher than in previous years.

Rice fields in Betsuma Chambeshi floodplain were flooded since January 2014, the highest reported floodwaters since 1999. Farmers lost their entire rice crop.

Rice field in Chembe Malata, knee-deep flooding depth; in normal years water depth is at 2-5cm

Zone 2: Medium Lowland: This zone is higher up the slope (relief), and includes both the floodplain and dambos. This zone floods later in the season and for only about one month, in March. Given its high ground water table, floodwater and rainfall, much water can be accumulated and stored in this zone. Drainage is also possible.

Zone 3: Upper Lowland: Similar to Zone 2, this is either an extension of the floodplain or a dambo. As it is higher up to the slope than Zone 2, most water in Zone 3 comes from rainfall and groundwater table and less from river flooding. Flooding is expected during the second half of the rainy season and for a shorter period of time than in Zone 2. Without additional water management options, this zone is vulnerable to drought in years with little rainfall. During the past two years, farmers in Chinsali have lost their rice crop to drought in this zone.

Zone 4: Upland Zone: This zone is used for growing all other major crops, including maize, legumes, cassava, sweet potato, groundnuts, and soy beans. Crops depend on rainfall only and there is no seasonal flooding. Rice is not planted in this zone.

3.6. Adaptation to climate variability – opportunities for intensification

Distinguishing the three separate lowland zones allows us to better target interventions. Vulnerability to drought or flooding is different in each of the three zones, and adaptations can be adjusted according to these specific conditions.

Zone 1: Chambeshi floodplain

Farmers have limited management opportunities in the floodplain. Priority should be given to planting early in the season with one young seedling/hill and wide spacing. Mechanical weeding can be done as needed until the depth of the flooding exceeds five cm, at which point weeder application is no longer efficient. With early planting, farmers will have from four to eight weeks to properly manage the vegetative phase, including multiple weedings, so that plants can tiller well before the water depth exceeds five cm.

Zone 2: Medium Lowland

In this zone there is a greater potential for good management and stabilized, high-yield rice production, especially if irrigation and drainage are put in place. Small ponds can be dug, which will fill rapidly from the high water table. Treadle pumps, which can irrigate two limas (½ hectare)/day can be used to irrigate as needed from the ponds. COMACO has already distributed many treadle pumps for vegetable production in the area. Bunding of fields maintains water levels in the plot or helps drain water if necessary. Theses measures to add or drain water will allow farmers to take full advantage of the SRI practices.



Treadle pump | Hand dug small pond (white arrow) to irrigate the vegetable garden | 1 treadle pump can irrigate ½ ha/day (2 limas)

Farmers use treadle pumps into the dry season, when high groundwater table allows for continued irrigation. Wilson Mumbi (in the middle), lead farmer, Kawama, plants cabbage, tomatoes, onions

<u>Zone 3: Upper Lowland</u>

Management opportunities are similar to Zone 2. Ponds might need to be larger in order to assure irrigation during a dry spell. The ponds should be natural and not lined with cement, as water percolates sideways through the soil to fill the pond. Bunding of fields and hand dug canals for irrigation and drainage allow farmers to manage water without high infrastructure costs. According to those we interviewed, the water table is high and accessible for irrigation even after two dry years. Groundwater replenishes quickly after good rains. As soils are not waterlogged at the end of the rainy season, it is possible to do relay-cropping (planting a crop or cover crop into the maturing rice before it is harvested), or plant crops immediately after the rice is harvested, using irrigation water from the ponds for these crops during the dry season. Cover cropping is a good strategy for improving soil fertility. For farmers, such lucrative dry season activities can replace cutting forests for charcoal production or poaching wildlife.

Plots in Zones 2 and 3 are often closer to the uplands and homestead than those in the Zone 1 floodplain, and thus easier for farmers to access, supervise and manage. Most stable rice yields can be expected in zone 2 and 3, if water and soil fertility can be managed.

3.7. Chama rice quality loss

The quality and aroma of Chama rice from Chinsali has been steadily deteriorating over the past four years, obliging COMACO to market this rice as Nakonde or Chinsali rice, at a lower price. Here is what we found to be the problem:

In Northern Zambia, farmers grow what is known as “Super Rice,” a mix of varieties from Zambia, Tanzania, and Malawi with aromatic characteristics, but with a quality generally inferior to Chama rice.

When COMACO expanded into Chinsali in 2010, 20 tons of Chama rice seed were distributed to the farmers. Each farmer received 20 kg as start-up seed with the understanding that he or she would use his or her own seed the following season(s). Despite use of the distributed seed, the quality of rice produced in Chinsali was inferior to that of the Chama rice grown in the East, and quality continued to deteriorate in the following years.

The main reason for this problem has nothing to do with the soil or climate conditions. It is because Chama rice is getting mixed with Super Rice, and the proportion of the inferior Super Rice increases each year. This unexpected problem is rooted in the nature of the broadcast system.

To plant rice by broadcasting uses a large amount of seed (80-100 kg/ha or more), creating a very high planting density with randomly and very narrowly spaced plants. One rice plant produces only one to three tillers. It is very difficult to identify individual plants. In a field of one to two hectares, it is impossible to systematically identify and eliminate contamination within the field by a foreign variety other than Chama rice.

There are a number of ways this contamination can happen: 1) some minor contamination with Super Rice seed can occur during the handling the Chama rice seed before planting or after harvesting; 2) Super Rice grains that remain in the field from the previous year germinate together with the Chama rice after being seeded. Again, in a broadcast system, it is impossible to identify and separate last year's rice from newly seeded rice; 3) at harvest, all the rice is bulked together. Thus, the mixed-in varieties are harvested together with the Chama rice; and 4) when the farmer sets some of the seed aside for following year, it is already contaminated.

Once a minor mixing of seeds takes place in a broadcast seeding system, it becomes impossible to separate and purify the varieties again. The seed stock will slowly deteriorate.

Some farmers are aware of this. In the village of Betsuma, farmers do make the effort to physically separate the location where they grow Chama rice, and have been able to keep the mixing of varieties to a minimum. Nevertheless, as explained above, in the long run it is impossible to avoid contamination using a broadcast system.

Using SRI practices, it is easy to maintain seed quality of Chama rice and even to purify mixed varieties. This is how: SRI planting practices use single seedlings with wide spacing between each plant. Only 6-8 kg of seed are needed for one hectare in contrast to the 80-100 kg/ha required under the broadcast system. Because the plant population is so much lower, it is easy to identify a foreign variety growing in a field of Chama rice, and farmers can easily uproot these individual plants throughout the cropping season. In order to create a good seed stock for the following year, farmers can harvest panicle by panicle from the best Chama plants in the field. This is possible because only a small amount of seed is required. In Mfuwe, farmers already follow these practices, transplanting Chama rice with wide spacing and harvesting their seed panicle by panicle - thus maintaining excellent quality (see Mfuwe section for details).

The other challenge for COMACO, not addressed here, is to verify rice quality when farmers deliver their rice for sale to COMACO in 50kg bags. A control system needs to be put in place. However, this seems not to be an issue in Mfuwe, where most farmers plant only the Chama variety, apply SRI methods and harvest panicle by panicle.

Some remarks about improved varieties

As the dominant rice varieties are local from within the larger geographic zone around Chinsali, it was asked if any improved varieties had been introduced. The only varieties introduced are Nerica 1 and 4, but these have not been planted other than in demonstration plots, as these rices offer no advantages to either farmers or consumers, for different reasons. For farmers, these are upland and short cycle varieties, not well suited to dambo conditions and long rainy seasons. And, as noted above, growing rice in the uplands cannot be recommended, as it would directly compete with upland crops and be more vulnerable to dry spells. For consumers, these varieties lack aromatic flavor and turn to "porridge" when cooked. Both rural and urban consumers in Zambia prefer local rices like Chama and Mongu for their aroma, color, shape and cooking qualities.

3.8. Implementation strategies for rice intensification for the 2014/2015 cropping season

An implementation strategy for improving Chinsali's extensive rice production system must consider characteristics of the different zones, farmers' knowledge and interest in applying the SRI methodology, and the challenge of expanding the SRI area beyond small test plots. The implementation approach should:

i) Be easy for farmers to implement,
ii) Create clear successes and tangible benefits for farmers, and
iii) Provide farmers the support and benefit (knowledge, material, financial rewards) to continue adopting sustainable intensification practices.

The below outlines a pilot for the 2014/2015 cropping season, focusing on geographically selected areas where careful design and successful implementation can serve as a model for innovation. Building on the first year's success, outreach can be expanded the following year.

1) Go beyond demonstration plots and work directly with farmer groups

Demonstration plots have been very well implemented, allowing farmers to observe the improved crop performance in SRI plots over the current cropping system. Nevertheless, the uptake of SRI beyond demonstration plots is not yet significant. A different approach--directly working with farmer groups-- is recommended. Close technical backstopping is needed so that farmers understand how to implement SRI practices well and become more confident in doing so. It is obvious that this transition will be more difficult for farmers who practice an extensive crop management approach (as in Chinsali), than for farmers who are already intensifying (as in Mfuwe).

2) Organize farmers in groups

During the dry season, begin discussing with lead farmers how to organize farmers in groups. The lead farmers can help identify and mobilize a group (maximum 15-20) of motivated farmers interested in developing improved cropping practices. It may take several visits to the farming communities for COMACO staff to set this up. Farmers who volunteer out of interest are ideal candidates. The idea is to group SRI plots in one location, so that farmers can help each other learn the new skills required, such as transplanting and weeding. A common nursery for the farmer group can be established, sown in staggered intervals, permitting access to young seedlings when needed.

3) Cluster SRI plots of 10-20 farmers in the medium lowland zone (Zone 2)

Zone 2, the most productive lowland zone, is also the zone where measures such as irrigation and drainage through hand dug canals and ponds can be taken to adapt to climate variability. By selecting the right location, it will be possible to showcase high rice productivity independent of the weather, be it a drought year or a year with excessive rain and flooding. If farmers understand that rice productivity can be stabilized through improved water management, the step towards intensification will be much easier.

Pilot in the floodplain: A similar pilot can be undertaken with farmers who grow rice only in the floodplain. SRI fields should be transplanted early in the season, and farmers should be supported with technical backstopping and equipment, such as weeders. Ideally, the rice crop should develop to the flowering stage about the time when the flooding arrives. The timing for various management interventions will change from location to location and from year to year, but farmers can work within the guidelines of the SRI principles and adjust the practice to best of their ability. SRI yields in the floodplain can easily be tripled from <1 t/ha to 3t/ha. Given the increased yields, area under rice can be reduced by half or two thirds, allowing farmers to better focus on improved crop management.

It is important to create a group dynamic so that farmers can support each other in changing their production practices.

4) Start small

For the initial learning experience, it will be most effective if each farmer starts out with a small plot (suggest ½ lima/ 1/8 hectare), and commits to implementing SRI correctly on it. Starting small will minimize the time and effort required and increases the chances of success.

5) Commitment to SRI and good technical backstopping on SRI practices

Farmers will be expected to follow SRI practices to the best of their ability. COMACO staff will commit to providing good technical backstopping, which means being present when important technical steps (nursery establishment, transplanting, etc) are undertaken for the first time.

6) Additional technical assistance and training for soil fertility management

Soil fertility degradation is a main constraint in Chinsali. Improved techniques to increase soil fertility, such as use of leguminous plants for cover crop or improved fallow systems, should be explored with farmers. Mucuna and cowpeas are already known and perform well; the next step is to adapt their use to better integrate with the SRI techniques. Minimum tillage and innovations such as mulching with weeds and crop residue management, as practiced in Mfuwe (see next section) should be tried in Chinsali.

7) ***Commit to high quality Chama rice production with SRI***

This point is essential!

Chama rice seed production using SRI will enable farmers in the Chinsali region to transition from the currently-grown mixed, lower quality rice to growing pure Chama rice. COMACO can bring in good quality Chama seed for this pilot, and work closely with farmers to focus on producing pure Chama rice by eliminating foreign varieties during the cropping cycle and by harvesting panicle by panicle, as discussed above. The rice produced in the pilots can be sold for seed at a premium price.

8) COMACO's role

- Assist in organizing initial farmer groups per location.
- Provide equipment and materials, such as treadle pumps, weeders and other simple labor-saving tools to the farmer groups organized around clustered SRI plots
- Assure technical backstopping to see that SRI practices are well implemented.
- Offer premium prices for pure Chama rice seed grown using SRI practices.
- Work with farmers on expansion of the area under SRI for the following year, including what type of organization and support (technical training, materials) may be needed.

9) Create "hubs of innovation"

It will take involvement by a critical mass of farmers to create long-lasting change. These pilot areas should be strategically located across the implementation zone, and serve as "innovation hubs" from where new knowledge and innovative practices can spread. Field days and exchange visits can bring farmers from the surrounding area to the SRI plots learn about SRI and see its success for themselves. In addition, it will be critical for COMACO to provide incentives such as premium prices for rice, and access to tools and materials to support this transition.

10) Beyond the first year: Expansion of SRI area and production of high quality Chama rice

It is of great importance to be successful in the first year. Expected results are:

- Farmers and COMACO technicians should learn how to best develop SRI practices that are well adapted to the three lowland zones. Repeated field visits, exchange visits, and discussion with farmers will guide this process.
- High productivity of the SRI fields, with decreased vulnerability to climate variability.
- Chama rice is produced as a pure variety and can be sold as seed, and eventually in large quantities for the market.
- COMACO develops a strategy with the rice-producing communities for expansion of the area under SRI for the following year, and what trainings and outreach activities will be needed to reach out to the other community members.

The transition to SRI will allow farmers to reduce their area under rice cultivation while obtaining the same amount of production, and will take less of their time for soil preparation and traveling between dispersed and distant plots. Farmers should be able to reach yields of 3-5t/ha, and produce high quality Chama rice.

It is unlikely that all rice surface areas in Chinsali will quickly transition to SRI, but with the right combination of a good approach for working with farmers, technical assistance, and incentives, adoption of improved practices might be faster than expected. The farmers in Mfuwe, who switched from broadcasting to transplanting and adopted parts of the SRI methodology, thus achieving good yields of 3-6 t/ha of pure Chama rice, are good examples. Exactly how the farmers in Mfuwe do this is presented in the next section.

4. Dambo Rice Production Zone, Mfuwe, Mwambwe District, Eastern Province

4.1. Agricultural system overview

The Eastern Province is situated in agro-ecology region 2 (and partially 1), and is characterized by rainfall of 800-1000mm (see map on page 9 and detailed description in Annex 2). Soils have a high natural fertility, especially in the lowland areas where rice is grown. Lowland soils are dark colored alluvial soils, rich in organic matter and nutrients. Rice can be planted in these soils without fertilization (Republic of Zambia 2011, 2014).

COMACO works in four districts in the Eastern Province: Chama, Lundazi, Mambwe and Nyamba. Map of COMACO intervention zone is shown on page 5 and Annex 3. During this diagnostic, field visits took us to the Mfuwe area in Mambwe district, where we met with farmers in the Chiefdoms of Nsefu, Kakumbi, Mnkhanya and Mwanya. Please note that findings and recommendations from this report should be confirmed and adjusted as necessary for Chama, Lundazi and Nyamba districts.

In Mfuwe, the rainy season covers a five-month period from November/December until March/April, a slightly shorter rainy season than that of Northern Zambia. Although the amount of rainfall is sufficient for crops to grow well, both rain distribution and periodic dry spells pose problems. Farmers face a different rainfall pattern every year, which makes it difficult to adjust agricultural practices.

<u>The main agricultural crops</u> in Mfuwe are maize, sweet potatoes, cassava, sorghum, cowpeas, and pumpkins as food crops for local consumption; and rice, groundnuts, soya and cotton as cash crops. As with Chinsali, all food and cash crops other than rice are planted on the uplands during the rainy season. Rice is planted in dambos. Farmers sometimes try planting upland crops (most often maize) in dambos, but unless it's a very dry year, these crops will die back upon flooding. As regards maize, farmers prefer open-pollinated maize varieties to hybrids as these are better adapted to drought conditions and are less infested by weevils during storage. There is no tradition of keeping livestock or fishing in the area.

COMACO began working in Mfuwe in 2002 by supporting following agricultural activities: conservation farming (including composting, crop residue management as mulch, tree planting), beekeeping and honey production, horticulture and vegetable production, poultry production for meat and eggs (sold to tourist lodges), as well as rice and groundnut production as cash crops.

4.2. Rice production practices and use of the SRI methodology

Until COMACO began working on rice in Mfuwe, it was only a minor crop there. The few farmers who planted it used the traditional extensive practice of broadcasting seeds on small areas, and the crop was entirely consumed at home, not sold.

In 2005/2006 COMACO began providing both Chama rice seeds and technical training to farmers. In 2009, Henry Ngimbu trained COMACO farmers and technicians on the SRI methodology. Today, COMACO employs two field technicians for rice, and works through village action groups (comprising a number of villages), producer groups, and farmer leaders. No additional technical trainings on rice have been held during the past few years, but field technicians continue working with farmers to reinforce what was learned before. Farmers who wish to produce Chama rice for COMACO receive 20kg of seed the first year. For the following seasons, farmers are responsible for producing their own seed.

Currently, COMACO works with more then 2500 rice farmers in Mfuwe, most of whom are women. For example, in the Nsefu Chiefdom, 80% (523 of 654) are women, and in Mwanya, 74% (292 of 394) are women. Even for those men who register, it is most often their wives who are responsible for the rice crop. According to farmers, rice is an ideal crop for women, including widows and unmarried women. Rice can be consumed by the family, exchanged for other goods, or sold to pay for their children's school fees. Women told us that rice is easy to grow; they can manage the technical details, and can adjust the size of the field according to their ability to cope with it. Most importantly, women can grow organic rice using their own resources, without depending on external inputs.

The other important cash crop, cotton, is most commonly raised by men. Cotton needs to be sprayed with pesticides at least seven times during a single season. Women do not like to do the spraying, and are therefore very content being able to grow organic rice.

Since COMACO's arrival, cropping practices have changed significantly from the previously very extensive system (similar to that in Chinsali) to an intensified agriculture that combines many innovative and sustainable practices, including SRI. It was difficult to fully understand during our short time in the field how these new practices evolved, but it seems that farmers benefited from various trainings on both rice and other crops, and then integrated the knowledge they gained to develop their current rice cropping practices. Thus, it is hardly possible to pinpoint one specific training or concept. It should be emphasized that COMACO's area managers and lead farmers played a crucial role in reinforcing the adoption of technical recommendations.

Rice is planted exclusively in large dambos, shared by 60-100 farmers, each with about ½ hectare, or 2 limas. Because these dambos are adjacent to their upland fields and close to the homesteads, it is possible for farmers to follow up daily.

Below is a summary of the very productive, innovative and ecologically sound practices that can be found throughout the area:

Soil preparation**:** Farmers either plow the land by hand in October and November, or not at all. In areas where the fertile soils remain moist and soft, farmers slash the herbaceous fallow vegetation, then let it settle and rot before transplanting rice seedlings directly into the mulch. Another strategy is to slash the fallow vegetation and weeds, but undertake careful hand plowing in patches where aggressive and difficult-to-control weeds grow. This is a very efficient strategy for long-term weed control.

Crop establishment and management:

Until 2004, farmers were broadcasting seeds. Today, all rice fields are transplanted!

Nursery: Farmers prepare a nursery at a low area in the rice field where water accumulates from the first rains. Sowing is done either before or after the first rains. If before, birds and monkey will not be able to identify the planting holes. 10-15 seeds are placed into one planting hole, and holes are spaced from 30cm to 50cm apart. Although this is an unusual way to establish a nursery, all farmers we talked to practice this method. The reasons are:

5. When 10-15 seeds germinate together they can break through the heavy soil crust that can build up when surface soil dries, where as a single seedling might not have the strength to push through the soil.
6. Rice germinates together with the weeds. As planting holes are widely separated, the nursery can be easily weeded using a hand hoe.

While seedlings develop in the nursery, the surrounding fields accumulate more soil moisture. Because rice fields are not leveled, some areas in the field accumulate water more quickly than others. Depending on amount of rain or flooding, farmers will transplant faster or slower into the humid or flooded areas. In years with high rainfall and moisture, the size of the fields can be expanded. In years with little rainfall or flooding, farmers may restrict the area planted. This planting strategy allows farmers to adjust to water availability (and thus to climate variability), and plant their crops only when enough soil moisture is available.

Number and age of seedlings: Some farmers transplant 1-2 seedlings/hill, others 3-4 seedlings/hill. The age of the seedlings when transplanted depends on how quickly the rainy season develops. Although farmers are aware that younger seedlings develop better, older seedlings are often planted when the rains are delayed. Richard Matemba, lead farmer in Nsefu, transplanted seedlings at about three weeks old this year. Because seedlings are transplanted only as the soil in different areas of a given field accumulates sufficient humidity,the age of seedlings within one field can vary considerably.

This can be seen clearly in the two pictures below, depicting the same rice field, planted by farmer Joyce from Kakumbi. This large field was planted over one full month. The seedling age follows a gradient across the field, from early planting with young seedlings to late planting with older seedlings. The height and development (and therefore the productivity) of the plants are significantly different.

Rice field of Joyce, Kakumbi Chiefdom (same field on the right and left)

Farmers plant in line, without using a string. Farmers explained that moving backwards when transplanting makes it easy to maintain a straight line using only the naked eye, however the lines might not be perfectly aligned across the field. As farmers have not had access to weeders, this has not mattered--so far.

Spacing between hills. During the SRI training, farmers were advised to space the seedlings on a 25cm x 25cm grid. Finding measurement in centimeters to be too “abstract,” farmers adapted this to 1 foot (about 30 cm), a measure more familiar to them. This is a useful farmer adaptation. Chama rice can tiller vigorously, thus the spacing of 1 foot or 30 cm is entirely appropriate.

Some farmers transplant seedlings by hand directly into the soil, others use a stick to make a hole. The latter is preferable, as the seedling roots can be placed vertically into the hole.

Weeding is done by hand. Farmers have only hoes with large blades, difficult to use for weeding within a rice crop, although possible for the nursery. Weeding is usually done twice: i) first time by hand (and some by hoe) 1-2 months after planting but before the flooding, ii) second time after the rice is flooded, and done entirely by hand.

Fertilization: As Chama rice is produced organically; farmers do not use fertilizer and do not add any compost or other organic matter. Soils are fertilized through slashed weeds and crop residues kept in the field (see below). Soils are also built up with fertile topsoil deposited by the floodwater. Nevertheless, dambo areas are very diverse, so soil degradation issues need to be kept in mind and addressed if necessary.

Pest and Diseases: Chama rice does not suffer from any disease or insect pest problems, but birds, rodents, and monkeys can dig out newly seeded rice grains. Elephants are a major problem at harvest. They feed on the rice fields at night, and can fully destroy any harvest. Before harvest, women spend the nights in the fields, lighting fires and making loud noises when they hear a herd of elephants approaching. This is very dangerous, and farmers get very little sleep during harvest time. This is also the time when all upland crops need to be harvested (e.g. maize, groundnuts, cotton etc). Delays in harvesting due to lack of sleep mean a loss in both quantity and quality of the harvested products (e.g. cotton price will get reduced for over-ripe cotton). To deal with elephants, COMACO has developed an efficient system where male farmers (former poachers) scare the elephants away using chili powder bullets shot from specially designed plastic guns.

Water management: In areas where flooding comes quickly and forcefully, there is risk of crop damage and soil erosion. In such areas, farmers create embankments using slashed vegetation, weeds and soil to slow the water flow. These embankments are found mostly between two fields, not placed along contour lines as required for best water management.

Use of SRI methodology

The SRI methodology and practices have been well integrated into the current cropping system. Without much technical supervision and encouragement, farmers have developed a well-performing and productive rice system. Many farmers use 1-2 seedlings/hill, plant young seedlings with wide spacing, pay attention to improved organic matter management by recycling weeds and straw, and weed the fields as needed. Nevertheless, there is room for improvement through use of some technical refinements. They are discussed in section 4.4 below.

Use of conservation agriculture methodology

As discussed above, farmers have integrated certain conservation agriculture practices, including reduced plowing (no-till), and mulching of the rice fields.

The slash-and-mulch method has several advantages:

- No plowing is needed, which reduces costs and also protects soil biota, and soil organic matter from decomposition,
- If the water current is not too strong during the seasonal flooding, the slashed weeds intercept the silt carried by the water. The silt is deposited on location and contributes to fertilizing the field.
- Towards the end of the season, when the water recedes, the mulch layer helps to preserve soil moisture, which improves the grain filling of the crop.

This method was shown to us by Ms Mary Musanga from the Mnkhanya Chiefdom. She did not learn these techniques specifically for rice, but adapted them from a training on mulching maize.

Before transplanting, Mary Musanga slashed the weeds and transplanted the rice seedlings into the mulch

Another conservation agriculture practice used by farmers is the mulching with rice straw after harvest. Some farmers who harvest panicle-by-panicle leave the straw standing behind. Instead of cutting the straw at the base to spread across the field, as done in other places, farmers bend the straw at the base in order to create a mulch. The straw remains in place during the entire dry season, and will not be carried away by the wind. By the start of the following rainy season, the mulch layer is partially decayed, allowing farmers to plant rice into the mulch. This is a very innovative and efficient technique to protect the soils. It was not possible during a short visit to survey how many farmers apply this technique, but it should be included in future COMACO's technical trainings.

After harvesting the rice, farmers flatten the rice straw producing a thick mat fixed in place

Farmers informed us that in earlier times, they would rake the weeds and crop residues together and burn them. Mulching was unheard of.

Chama rice quality and seed production: Farmers harvest by either cutting the straw low with a machete and bulking the harvested rice panicles together or by harvesting panicle by panicle with a small knife. The first method will most likely include some contamination by grains from other local varieties whereas the second method will produce pure Chama rice. Although the second method is more labor intensive, it produces high quality rice that can be used as seed. Last year, drought in many locations across the zone created a seed shortage so that this year, seed for Mfuwe had to be imported from Chama. One possible solution may be to create hubs of seed production for the region. This will be discussed below.

This Chama rice was harvested panicle by panicle with a small knife, resulting in 100% purity

Yields are higher in Mfuwe than in Chinsali, due to both better soils and, more importantly, better crop management; but climate variability can influence yields considerably. On average yields are between 4-6 t/ha. Here are some reported yield figures from farmers:

Farmer	Location	Yields (t/ha)
Mary Musanga	Mnkhanya	2.4-2.8
Women's group	Kakumbi	4.8-6.4
Richard Matembe	Nsefu	4.8-6.4
Mose's wife	Nsefu	7.04
Farmer group	Mwanja	8.0 (good years)
		4-4.8 (bad years)


Highly productive, fully organic Chama rice field in Mwanja

4.3. Challenges and constraints

The main challenges for rice production in Mfuwe relate to climate variability. Patterns and amount of rainfall and flooding differs from year to year. To cite only the past two years:

2012-2013 was a drought year. A major dry spell occurred from January well into February. Rice planted in November/December turned brown and most farmers harvested no rice at all. Losing their rice crop meant losing needed income, and poaching levels started to rise again during the following the dry season. The few farmers who were able to harvest that year planted in locations with adequate soil moisture accumulation and applied conservation agriculture practices to conserve soil moisture.

In 2013-2014, the rainy season started very late and early rainfall distribution was spotty. Only in January did it rain sufficiently for planting, thus many farmers planted as late as the end of January, although the ideal planting time is from November 15 to early December. The rainy season ended from mid-to-late April. Crops that were planted late showed moisture stress during the grain filling and maturing phases, which will result in yield reduction. Farmers who planted their crops early and managed soil moisture well were able to obtain a good harvest.

These examples show how rainfall conditions can differ from year to year.
A number of strategies, explained below, can enable farmers to adjust to various rainfall situations.

4.4. Opportunities for intensification

Improving rice production using SRI principles and practices

A refresher training on SRI for technicians and farmers is needed, but should not be limited to an introduction to SRI. Training should focus on a clear explanation of SRI principles followed by discussion about the pros and cons of standard SRI practices versus the adapted SRI farmer practices. The outcome of this process will subsequently influence the content of COMACO Learning Pages and other training materials. To give an example: It is quite likely that most farmers' nursery practices are better adapted to the dambo environment than the standard SRI nursery practices. In this case, it would be a mistake to recommend that farmers change what they already do. In-depth discussions with farmers and further trials can help to confirm or further develop well-adapted practices, and refine recommendations for optimal implementation of SRI and conservation agriculture techniques.

<u>Soil preparation and soil management</u>: Farmers have already developed good soil conservation practices for rice. During the next season, COMACO staff should confirm the good practices, assess where they are commonly used, and describe them in more detail. This information will influence the training approach and production of appropriate Learning Pages on the various topics. Practices to investigate are: i) no-till of dambo soils, ii) slash-and-mulch of weeds and transplanting rice seedlings into mulch, and iii) bending over standing rice straw following harvest to create a mulch that is fixed in place.

<u>Plant establishment:</u> a number of practices can be improved. Tests should be done for:

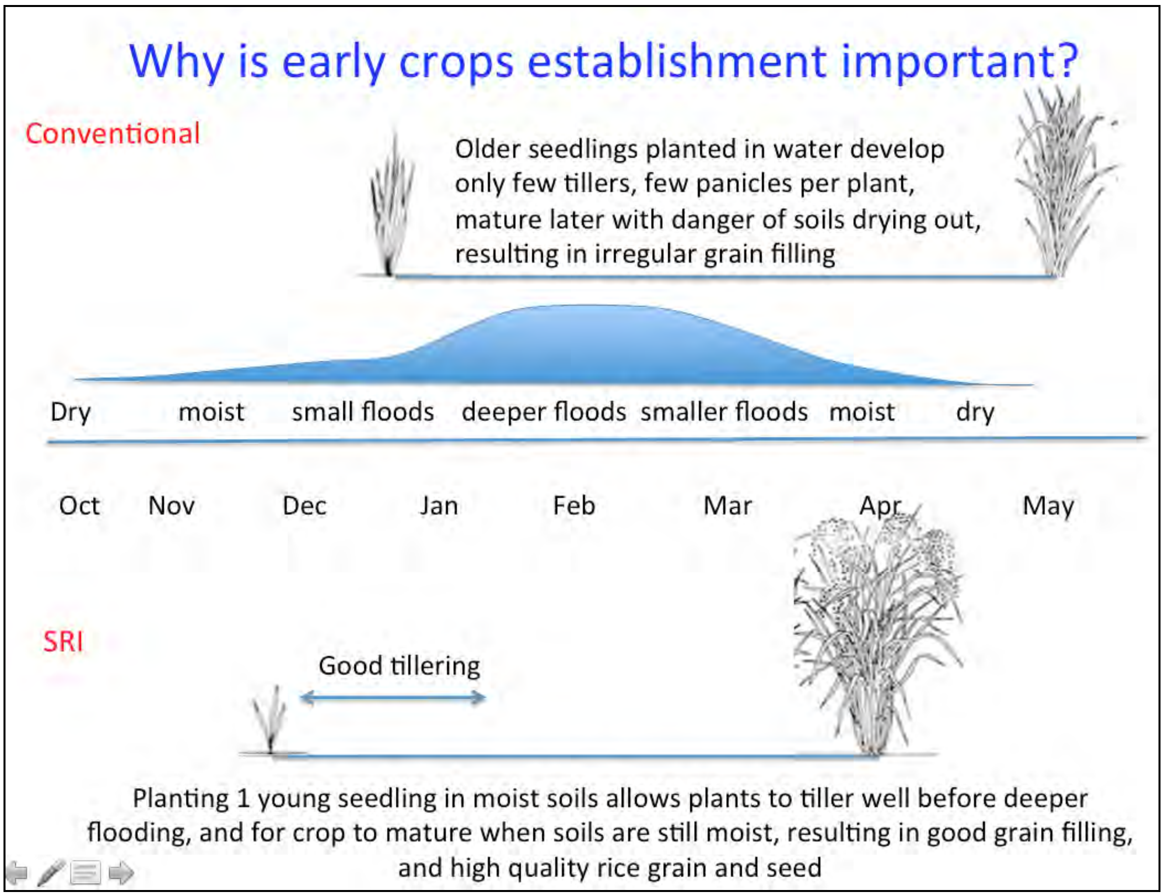
iii. <u>Seed soaking</u> for 24 hours before seeding will allow quicker germination, and eliminate non-viable seeds.

iv. <u>Nursery</u>: The farmers' present nursery techniques can be compared and tested against the standard SRI nursery practices. It is possible that farmers' nurseries are better adapted to local conditions than the standard SRI nursery. To be useful in this environment, the soil used for standard SRI nurseries should be mixed with sand to create a lighter seedbed, allowing single plants to germinate well. It is uncertain if this is feasible and economical in the dambo environment. Seeding 10-15 seeds/hill may be better adapted to the heavy soils.

- <u>Age of seedlings</u>: Although farmers know that young seedlings produce better, they often use older seedlings because it might take several days or weeks to transplant a field, which creates a wide variance in seedling ages in the same field. It can be recommended to sow the nursery in several stages, each staggered a few days apart, so that farmers will have young seedlings available over the entire course of the transplanting period.
- <u>Number of seedlings</u>: Although a few farmers planted one seedling/hill, most planted two or 3-4 seedlings/hill. Trainings should focus on reintroducing the idea of transplanting only one young vigorous seedling/hill. To do this successfully, the seedling must be young, as older seedlings do not tiller well. Also, if non-viable seeds are eliminated through seed-soaking, overall seedling survival and development will be improved.
- <u>Spacing</u>: Farmers currently space the hills at a distance of one foot. This is reasonable, an easy measure, and can be integrated as such in training materials and Learning Pages.

- Planting in line: Although many farmers seem to know how to plant in line by the naked eye, it should be confirmed that this skill is widespread. Introducing different types of markers can help to establish the concept of grid-patterns.
- Planting early into mud and before flooding: Farmers tend to wait until the fields are flooded before planting. There are several advantages to planting when soils are muddy, prior to flooding:
  - Fields are planted earlier in the season
  - Seedlings will be transplanted at a younger age.
  - Plants will benefit from a longer period of aerobic soil conditions and thus tiller and develop better
  - An early start results in early maturing, assuring that the grain-filling phase takes place when soils are still humid.

  Planting early has many important implications for successful crop management, as summarized in the figure below. The same principles are also valid for the floodplain and dambo system of Chinsali.



Weed management using simple mechanical weeders can save labor, but requires planting in line, ideally in a grid pattern so weeding can be done in two directions perpendicular to each other. If farmers apply slash-and-mulch practices, weeds are suppressed by the mulch layer and if needed can be removed by hand. Both of these systems greatly reduce the amount of labor needed compared to the common system, where fields are not mulched and weeds removed by hand.

Pests: birds and elephants are the most serious pests. Some farmers stretch plastic tape from video or sound cassettes across the fields to frighten away the birds, an effective method that could be more widely publicized. To deter elephants from foraging in rice fields, COMACO has developed an inventive methodology using chili powder "bullets," which should be systematically employed during harvest.

Seed production: COMACO should encourage farmers to produce high quality seed. Focused training, technical backstopping and a premium price for seed-quality rice can induce farmers to make the additional effort to harvest panicle by panicle, necessary to produce high quality Chama seed rice.

Designating certain villages to become seed producers for the region will make COMACO and the rice producers less vulnerable to recurring droughts and dry spells. The village of Mwanya would be an ideal candidate, as their dambos have very good soil fertility and retain enough water to produce rice even in drought years.

Chama rice: good grain filling achieved with SRI and good soil moisture

Water management: Water management can be improved both at the plot level and at dambo level. Farmers who share one dambo for planting could discuss how water flows through the dambo and how it can be best managed to the benefit of all. Embankments might be positioned to follow contour lines in the dambo basin, not only to delineate fields. Other water management measures to be considered are digging ponds or canals to help in supplemental irrigation or drainage (integrating the use of treadle pumps) depending on need.

Although farmers we interviewed had not discussed these issues with their neighbors, they thought it was a good idea. COMACO staff could facilitate these discussions. Farmer groups might be able to identify some simple solutions for improved water storage, which will help stabilize rice production despite the variable climate.

Soil water conservation can be significantly enhanced through mulching, less tillage and soil disturbance, and by keeping straw from the previous season in the field during the long dry season.

Improving the implementation approach

Farmers in Mfuwe have already developed good rice production practices. The aim should be to further improve them and to share them with farmers in the other Eastern Districts and Northern Districts where COMACO intervenes. A number of approaches can be developed:

Staff and lead farmer training

- Refresher training for COMACO's technical staff and lead farmers to create a common understanding of the SRI methodology and associated good practices (e.g. conservation agriculture methods). Staff and lead farmers from Chama, Lundazi, Nymba should be included.
- Visit rice sites in Chama, Lundazi and Nymba in order to understand their current rice practices and adjust training modules and training approaches to fit.
- Trained lead farmers will train farmer groups. Farmers should work in groups to implement newly-learned techniques and practices.

Exchange visits

- Organize exchange visits within the region for farmers from Lundazi, Chama, Nymba, and Chinsali to visit farmers with rice fields showing well-implemented conservation farming and SRI practices in Mfuwe. This will be the best and quickest way for farmers to learn about the improved practices. Farmers from Chinsali should have the opportunity to exchange at length and in detail with farmers in Mfuwe, providing Chinsali farmers with all the elements to transition from extensive to more intensive rice production practices.

Experimentation in farmers' fields

- Discuss with farmers and advise them as to what type of trials they would like to undertake in their own fields.
- Monitor the trials and discuss how to further improve practices.
- Organize field visits (open field day) for farmers planting within the same dambo to obtain their inputs and opinions on farmer trials and new ideas.
- Motivate farmers to spread their knowledge, testing and experimenting.

Technical backstopping and data collection

iv) COMACO technical staff should visit farmers' fields and monitor the performance of trials and new practices.
v) Data should be collected on comparative yields of different farming practices. Lead farmers can also be trained in data collection.

Technical materials and training materials

➢ Create Learning Pages and extension manuals for distribution to farmers

- ➢ Technical materials should differentiate between the Northern and Eastern Regions
- ➢ Technical materials should be revised and adjusted each year based on a post-cropping season evaluation, to be ready and distributed to farmers before the beginning of the following rainy season.

"Harvesting guidelines" as well as schematic presentations of a "SRI Planning and Field Preparation Timeline" and "SRI Crop Management Timeline" can be found in Annex 5,6 and 7, respectively.

5. Final conclusions and recommendations

Conclusions and recommendations were provided above for both the Northern zone and the Eastern zone. A summary of conclusions and recommendations follows:

- Rice yields can be increased and stabilized (despite climate variability) in the Northern Province as well as in the Eastern Province
- The Chama variety and other local varieties have a very good yield potential (4-6 t/ha) that should be achieved using technical recommendations identified in this report.
- Chama rice grain quality can be improved with technical recommendations identified in this report. Highly productive Chama seed production can be assured with SRI.
- In Mfuwe there is a real potential to further improve and stabilize yields by fine-tuning farmer practices, and most importantly by disseminating knowledge about these practices for large-scale uptake.
- In Chinsali, it is important to create successful pilots from which the program can expand in the following year.
- An effective monitoring system should be developed, with comprehensive data collection that will allow COMACO to measure progress, and help the technical team and farmers to maximize understanding and learning from what happens in the field.
- Refresh and deepen technical SRI training, organize exchange visits and active learning with farmers. Revise technical materials and learning pages on a yearly basis, adjusted to regional conditions.
- Encourage farmer innovation and experimentation through lead farmers, and organize open field days around innovations in farmers' fields.
- Introduce simple tools (weeders, markers) to improve labor productivity and encourage farmers to sustainably intensify the rice system.

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Annex 1

Program of Zambia Visit by Erika Styger

Date	Activity	Comments
April 13/14	Flight from Syracuse to Washington DC to Johannesburg to Lusaka	Arrival in the evening
April 15	Lusaka, trip organization, meet with Richard	
April 16	Travel by road from Lusaka to Chinsali with Richard; Stop at Serengy office; Stop at Chinsali office	925 km (Lusaka – Chinsali), 11 hours
April 17	Field visitsKawama, Cheswa, Chintankwa	Field visits with Richard Mumba, Emmanuel, Henry Ngimbu
April 18	Besuma, Chembe Malata, Debriefing with project staff in Chinsali	
April 19	Travel from Chinsali to Lusaka	925 km (Chinsali – Lusaka) 11 h
April 20	Lusaka – Resting day,	Easter Sunday
April 21	Travel by road to Chipata, meet with Dale Lewis	> 600 km (8 hours)
April 22	Visit ICRAF at Msekere research station; check in the Chipata office, drive to Mfuwe; meeting with staff and introduction to COMACO's work in Mfuwe	Chipata, Mfuwe
April 23	Field visit to Nsefu Chiefdom	
April 24	Field visit to Mwanjia Chiefdom	
April 25	Field visit to Kakumbi and Mnkhanya Chiefdom	
April 26	Debriefing Mfuwe office, game viewing late afternoon	
April 27	Drive to Chipata, Interview for Comaco Radio, dinner with ICRAF delegation	
April 28	Chipata office debrief with Mr Data, travel from Chipata to Lusaka	> 600 km (8 hours)
April 29	Workplan development with Henry Ngimbu	Comaco office, Lusaka
April 30	Debriefing and powerpoint presentation to Dale Lewis, Richard Mumba, and Norwegian embassy	Comaco office, Lusaka
May 1st	Flight from Lusaka – Johannesburg	
May 2nd	Washington DC - Syracuse	

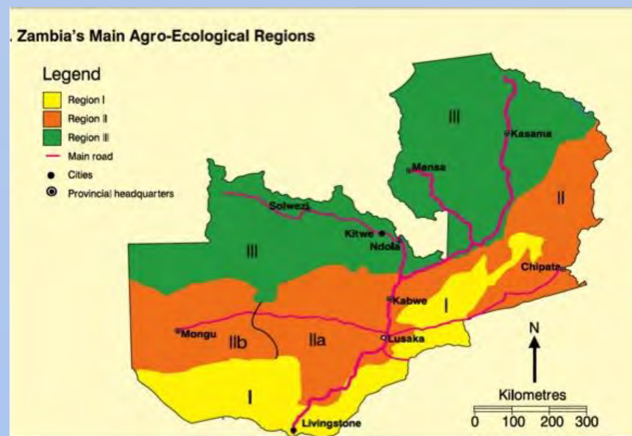
Annex 2

Agro-Ecological Regions of Zambia

The country is subdivided into 36 agro-ecological zones which are grouped into three agro-ecological regions. They are defined as:

Region I

- Low rainfall and drought-prone area (< 800 mm/yr), characterized by a short, hot growing season. Maize, sorghum, groundnuts, sunflowers and cowpeas are cultivated, and the fishing industry (though now in decline) has drawn many to the area. Mats and baskets are made from reeds and sold. There is potential for high-value vegetables, fruits and rice. This zone also includes major game management area (Luangwa Valley), where farming households attempt to coexist with wildlife.



- Covers 12% of Zambia's land area including the country's major valleys Gwembe, Lunsemfwa and Luangwa, and the southern parts of Western and Southern provinces.

Region II

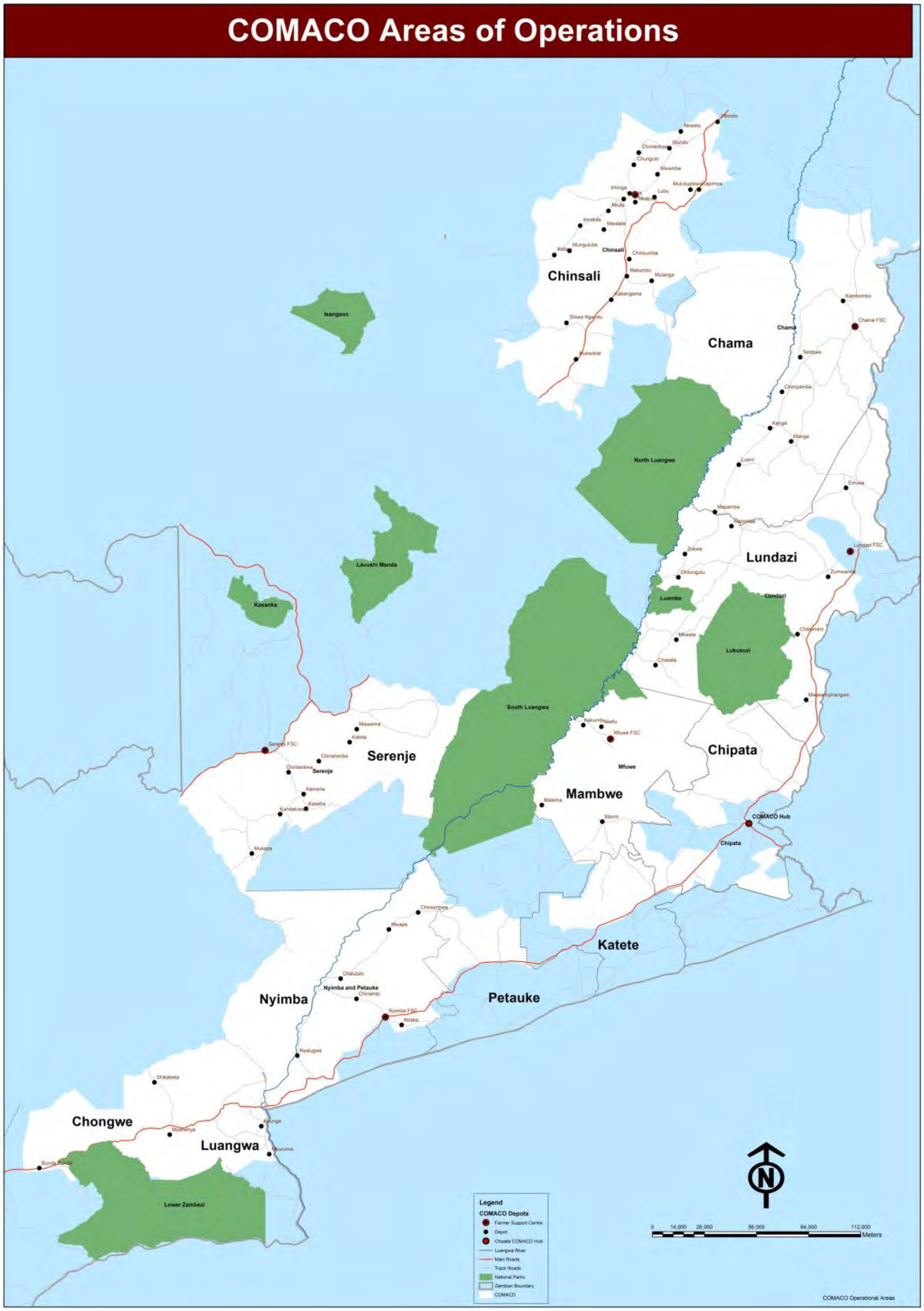
- Medium rainfall area (800-1,000 mm/y) running east-west through the center of the country, representing the most favorable agro-ecological conditions in terms of rainfall, soil quality, and absence of tse-tse fly. Presence of wetlands, dambos, rivers and lakes allows for water management opportunities, and, with good market infrastructure, support high-value crops and mix of crop and livestock enterprises.
- Maize is the staple crop, other crops include beans, groundnuts, sorghum, cassava, millet, sweet potato, sunflower, cotton, rice, tobacco, paprika along with vegetables (e.g., tomatoes and onions) and fruits (e.g., bananas, citrus fruits and guavas).
- This zone constitutes about 42% of Zambia's land area, of which 50% is available for agricultural use: Sandveld Plateau of Central and Eastern Lusaka and Southern Province, Kalahari Sand Plateau and Zambezi Floodplains of Western Province.

Region III

- With rainfall of 1,000-1,500 mm/yr and a growing season of 120-150 days, major crops produced are cassava, maize, groundnuts, millet, sorghum, beans and sweet potatoes, rice and small-scale fishing. This zone contains major river systems, such as the Luapula and Mansa rivers, as well as numerous lakes, dambos, and thus has high potential for irrigation and for fishing. The soils are more leached and not as fertile as in Zone II. This, along with poor market access, limits the number of crop types cultivated. Nevertheless, large water resources in the area provide a good potential for intensification of various crops, including rice, which has become in some areas an important cash crop.
- This zone constitutes about 46% of Zambia's land area, including part of the Central African Plateau covering Northern, Luapula, Copperbelt and Northwestern provinces, and parts of Serenje and Mkushi districts.

(Ref: IMWI, 2009; Sitko et al, 2011)

Annex 3


COMACO Areas of Operations
Chinsali
Chama
Lundazi
Serenje
Chipata
Mambwe
Katete
Petauke
Nyimba
Chongwe
Luangwa
North Luangwa
South Luangwa
Lukusuzi
Lavushi Manda
Kasanka
Lower Zambezi
Legend
COMACO Depots
Meters

Annex 4

Proposed Harvesting of Rice Plots in Chinsali and Mfuwe Area, shared with COMACO staff in May 2014

CHINSALI

Site 1: Kawama Village

- Demonstration plot managed by farmer Wilson Mumbi; this is a very nice demonstration plot and should be harvested very carefully, taking into account all the treatments that were implemented:
    - Age of transplanting: (8 d, 21 d (JICA), 45 d)
    - Weeding: i) no weeding, ii) 1x weeding, iii) 3x weeding
    - JICA plot vs SRI systems

  Harvest should be done either
    - With a $1m^2$ wood frame (take at least 3 samples – but better 5 samples per plot), or
    - By harvesting the experimental plots: eliminate 1m border, measure the field with a measuring tape, harvest crop

    Read harvesting guidelines carefully to get all the details

Site 2: Cheswa

a) Demonstration plot in the floodplain: there are two plots, a SRI plot and a conventional plot, each 20m x 15m in size; harvest both plots with the same procedure for each of the two plots (either $1m^2$ plots or harvest entire plot after removing 1m border all around)
b) Lead farmer demonstration plot in the floodplain: if not yet harvested, get some samples from that plot
c) Traditional floodplain plots: ideally take samples from 5 plots in the floodplain (minimum 3 plots), take note of crop management practices (see sheet attached)

Site 3: Besuma: this area was flooded when we visited. According to farmers, a few fields still produce. It might be difficult for COMACO to get to this area for harvesting. If it is not feasible, one option would be to call up lead farmers, and direct them with the simple procedures for harvesting: measure out an area of 20m x 20m (or whatever surface area is suitable for them), cut, thresh and fill paddy in bags to be weighed. The information on cropping practices would need to be collected as well.

Site 4: Chembe Malata: This was exclusively a floodplain; it would be good to harvest at least 3-5 different plots (as described above) for SRI and for broadcasting. The information on cropping practices would need to be collected as well.

Site 5: Chintankwa: this represents zone 3 (where groundwater table is high). Some of the rice fields were fairly degraded, where rice was grown 5 years in a row without fertilization; the yields from these plots will be obviously low. It would be good to harvest plots with different cropping history, successive rice production 1 year – 3 years -5 years (x3) (for instance) repeated twice (x2) for conventional (broadcasting) and SRI (x2) plots. Thus in total 3 x 2 x 2 = 12 plots.

<u>Other sites</u>: we did not visit any other sites, but COMACO should identify them and organize harvest. It will be important to

- Identify crop zone (Zone 1, 2, 3),
- Harvest SRI plots as well as conventionally planted/broadcast plots.
- Per site it is good to have 3-5 plots for SRI and conventional. If that is not possible, it is better to at least 1 or 2 plots than nothing.

MFUWE

In Mfuwe, all farmers have abandoned broadcasting and have adopted transplanting. Their techniques are about "½ SRI" and are already much improved from broadcasting. Nevertheless, there is still potential to improve this rice system with the SRI method. This 2014 harvest can provide good baseline information, so the improvements over the next 4 years can be easily shown.

For harvesting, there are no SRI vs Conventional plots as it is the case in Chinsali, but the plots are all '**current farmer practices'**. It will be important to collect data on the practices.

The Chiefdoms Nsefu, Kakumbi, Mnkhanya are close-by the COMACO office, thus it should be fairly easy to organize the harvests. It is recommended to make a list of the different rice production areas (= one dambo? to be verified) per chiefdom, and harvest 5 different plots / area. For instance in Nsefu there was an area where 108 farmers plant rice. COMACO can come up with a list of areas in the different zones. Best is to coordinate with lead farmers and then organize the harvest.

OTHER COMACO RICE PRODUCTION SITES

<u>Chiefdom of Mwanjia, and other rice production sites such as Lundazi, Chama and others</u>

The Chieftom of Mwanjia presents a bigger challenge, as it is very remote, so do the zones of Lundazi and Chama. For these zones it might be best to inform lead farmers to measure out an area with measuring tape, then harvest, thresh and weigh the bags.

- They can also count numbers of tillers and numbers of panicles of 10 randomly selected stations in the field (indicate how many plants were planted in one station), and indicate a few other crop management information.
- Indicate if the plot is pure Chama rice plot or is a plot with mixed varieties is important to ask.

Annex 5

Rice Harvesting Guidelines for Yield Evaluation for COMACO, shared with COMACO staff, May 2014

These guidelines can be used for undertaking a rice yield evaluation, be it for a demonstration plot, a farmer's plot, a SRI or farmer's practice plot, or any other rice plot.

When harvesting a farmer plot or a demonstration plot managed by farmers, the technician should make an appointment with the farmer for the harvest. Any harvest should have the farmers associated, including other farmers from nearby who can participate, witness and help out with the harvest.

Important: follow the exact same procedures for harvesting the various plots, for instance the SRI plot and the control plot. Use the same scale and measurement tools.

Depending on the materials available and the plot size, there are two possibilities for harvesting:

3. Harvest the entire plot
3. Harvest samples within the plot

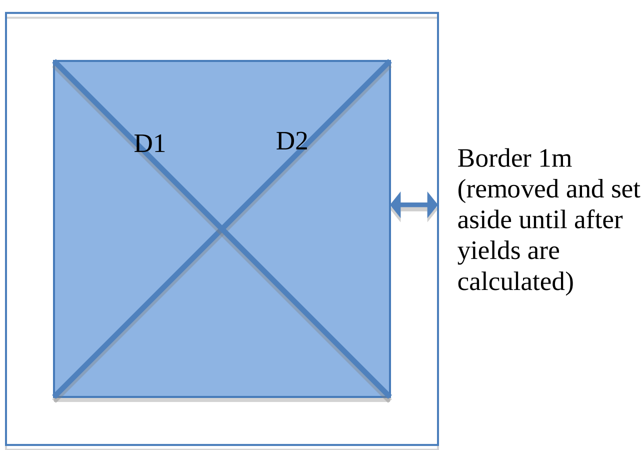
If the technician cannot be present, some simple but effective instructions can be provided to the farmers (over the phone for instance):

3. Simple harvest methodology when technicians/trained farmers are absent

3 HARVESTING THE ENTIRE PLOT

This can be done when i) the trial plot is small, and/or ii) no field scales are available.

Trial plot: for instance 10m x 10m (can be smaller or larger; can be rectangular or square)



Materials needed:

- Measuring tape (ideally > 20 meters)
- A shovel / hoe to dig up the 10 sample plants
- Harvesting scythe
- Scale found in the village (that can measure weight of the bags)
- Rice bags
- Materials for threshing and winnowing (what farmers usually use), including mats.

All the materials should be readily available in the village; a measuring tape might have to be bought at the market.

Step-by-step procedure for harvesting

Step 1: Observations before the harvest

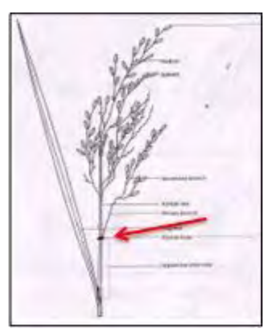
- Walk around the plot with the farmer or group of farmers, and discuss the evenness or unevenness of plant development within the plot. Discuss the reasons. Take notes.

Step 2: Remove the boundary around the plot

- Measure 1 meter from the plot boundary all around the plot, and harvest the rice of this border zone; set aside. The plants growing at the border of the plot show an edge effect, as plants develop differently (usually they show a fuller development, not having any neighbors on one side) compared to plants in the middle of the plot. To eliminate the boundary effect, the 1-meter band is eliminated all around the plot. If the plot is very small (only 3-5 meters long or wide), one or two plant rows can be removed. If the plot is very large, a 1.5 meter boundary can be respected. Set the boundary harvest well aside, so that it will not be accidently mixed in with the harvest of the yield evaluation.
- Once the boundary is removed, measure the square you are going to harvest in meters (length x width): Mark on the data collection sheet.

Step 3: Harvest 10 plants

- Before harvesting, walk carefully across the two diagonals of the plot, randomly harvesting five plants or hills on each of the diagonals. (In the SRI plot, 1 hill represents 1 plant, in the control plot, 1 hill represents usually 3-4 plants).
    - Measure the height of the plant (in cm): this is done with the measuring tape (mounted on a straight wooden stick): hold plant in your hand; slide your hand upward along the plant until the end of the last leaf or panicle; total height is measured from the base of the plant to where the longest leaf/panicle ends.
    - Cut/harvest the plant/hill at the base or dig it up (to keep the hill intact),
    - Take the 10 plants/hills individually out from the field and put them individually on a mat. Measure/count following variable and fill in the data collection sheet
        - Count the number of tillers per plant/hill
        - Count the number panicles per plant/hill



- Randomly select 5 panicles from the 10 plants,
  - Measure the length of the panicles (in mm!): place the panicle on a flat surface and measure from the panicle node (obvious mark, see flash in picture) to the top of the panicle.
  - If possible, count the number of grains of 3- 5 panicles
  - After taking all the measures in the field, add all the panicles from the 10 plants to the rice you will be harvesting next

Step 4: Harvest the plot

- Harvest the entire plot and collect all the grain in one location. Be careful not to mix it with the border harvest (Explain this to farmers ahead of time: to keep the two separated until the weight is determined)
- Discuss with farmers if it is necessary to dry the paddy before threshing and follow their advice. If paddy shows still signs of green, it is best to dry the paddy in a shaded environment for 2-3 days to loose excess moisture. Drying the paddy in the sun should be avoided, in order not to loose too much of its moisture content (and thus loss in weight). If the paddy is stored and dried for 1-3 days, there is also a danger for the grain to be disturbed or lost (due to animals, wind, etc.)
- Ideally the harvested rice should be threshed and winnowed as soon as possible, followed by measuring the weight as soon as possible.

Step 5: Measuring yield

- If a scale is available: weigh the paddy, [and write into datasheet]
- If no scale is available: use a measure of **Volume** that farmers usually use. This can be a rice bag of 50 kg or in some places, farmers make their own volumes (calabash or others). Get to know how many kilos the Volume holds. (In Zambia a 50 kg rice bag holds between 38-42 kg of rice, or an average of 40kg). Villagers might have an idea on how many kilos a volume holds, but it is best to weigh a Volume with rice filled. Then deduct the weight of the empty Volume container to get the kg of paddy/Volume. As you know the harvested area (m^2), you can calculate the yield of kg/ha.

Step 6: Calculating yield

- Kg of paddy / volume x number of volumes = total paddy harvested in kg
- Yield: kg harvested paddy / surface area m^2 * 10,000 = kg/ha
- Example: on a 400 m^2 plot, the harvest is 325 kg. Yield: 325/400 *10,000 = 8,125 kg/ha, equal 8.125 t/ha

Measurement units

Weight:
- 1000 grams (g) = 1 kilogram (kg)
- 1000 kg = 1 metric ton = 1 ton (t)

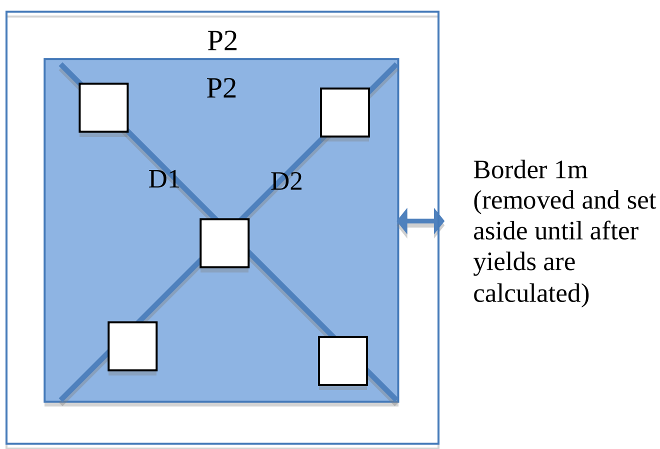
Area:
- 1 hectare (ha): 100 m x 100 m = 10,000 m^2

2. HARVESTING SAMPLES WITHIN A PLOT

This method is used, when i) the plot is large, and ii) a precision scale is available.

Materials needed:

- Harvesting frame of $1m^2$;
- Precision field scale (this is preferably a scale with smallest measurement unit being 10-50 grams), recommended is a PESOLA 1000 g scale.
- Moisture meter
- Medium thin plastic bags (5-10) for weighing the rice. If the samples are being taken back to he village a paper label must be placed inside the bag. The precision scale is calibrated with the bag attached to the scale.
- Measuring tape
- A shovel / hoe to dig up the plant
- Harvesting scythe
- Rice bags
- Materials for threshing and winnowing (what farmers usually use)



Step-by-step procedure for harvesting

Follow the steps 1, 2 and 3 as described above.

Step 4: Harvest of 5 sub-plots

The harvest data collection is done on 5 squares, each 1m x 1m in size. Procedures for SRI and control plots are the same.

Harvest squares: a rectangular wooden square is put together, 1m x 1m, preferably with light sturdy wood. The inner length of the wood square is exactly 100 cm! You should let the carpenter know that it is important to be precise, and before you accept the finished product, verify with the carpenter the accuracy of the square, in case there is a need for correction. It is also possible to produce a square out of metal.

In case there is no square available, it is possible to use the measuring tape. Four people hold each on to a corner of the measuring tape; when the angles are 90°, the tape can be lowered to the base of the plants as shown in the picture above.

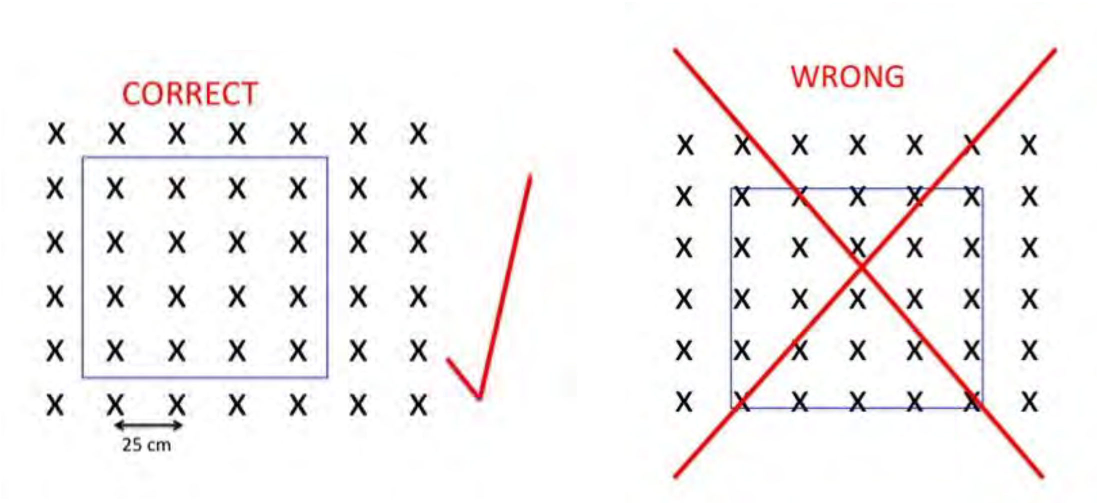
The placement of the squares **:**

- 5 squares are placed on the two diagonals as shown in the sketch above. The squares should not be placed side by side. Minimum distance between the squares is 1m. Where exactly the squares are placed within the field is a judgment call for the technician. If the field is uniform, the squares can be distributed randomly within the field along the diagonals. If the field is not uniform [this was identified under step 1], the technician should think about placing the squares in order to represent the field conditions. For instance: two squares can be placed in the better part of the plot, one square in the middle part and two squares in the inferior part of the plot, so that the overall sampling of the 5 plots represents an average of the entire field. This is of course an estimate, but all yield measurements are estimates, the task it to make sure the estimates are as good as possible!

- IMPORTANT: Place two **sides of the square exactly in the middle between two lines of plants**, and do not put the square at the base of a plant row. This could cause an error as explained below.
- Example: spacing between hills is 25cm, there are four plants within 1 meter (1m divided by 25cm = 4 plants). In one square meter, this is 4 plants x 4 plants =16 plants.

- DO IT RIGHT: The frame is to be put in equal distance between two plant rows!

- AVOID THE ERROR: If the frame is pushed towards the base of the plants within a row, it might be possible to include 5 lines of plants instead of 4 into the 1m^2 square, which can lead either to 4 x 5 plants = 20 plants, or even 5 x 5 plants = 25 plants, which will increase the yield falsely by 56%!.



Thus, placing the square needs to be done carefully. Take your time and count the number of plants within the square and adjust if necessary, before the cutting is done. For the control plot (which might not be planted in line), try to align **two sides of the square** the same way, placing the frame in the middle between two plants, even though there might not be clear lines as in the SRI treatment. There is no control where the third and fourth side of the square will fall, which is fine.

Harvesting of the plots: Five plots of 1m x 1m. Different scenarios are described below, depending on availability of materials.

i) Precision scale and moisture meter are available at harvest in the field:

- The square is cut very carefully. The number of plants/hills within the square are counted and marked on the form. (you can also do that after cutting, by counting the number of hills of stubbles)
- Once cut, threshing and winnowing of 1m x 1m square is ideally done on site with the help of the farmer on a mat that is brought to the field.
- The grain weight is determined with the precision scale. Grain moisture content is determined at the same time!

ii) Precision scale and moisture meter are not available at harvest in the field, but at the office

- If the weight cannot be determined on site, the rice of the 5 squares is placed in 5 bags with paper labels (indicating the name of the plot, if it is SRI or Control, date of harvest; labels should be written with a pencil and not with a pen. Pencil writing will not smear when in touch with moisture). Weight can be measured at the office, at the same time moisture needs to be determined.

iii) Precision scale is available but moisture meter is not available

- If no moisture meter is available: Rice samples are dried in shade for 2-3 days. This can be done by simply opening the bags, and store them at a safe and dry place, where no rodents can reach, and where the samples are not knocked over by accident.
- It is not advisable to dry the grains in the sun, because the grains can lose too much moisture when exposed to the sun for too long.
- Weight is determined with precision scale, and results marked on the form.

iv) Precision scale is not available

- In that case, the one square meter harvesting method is not appropriate, as the precision needed will be lacking. Thus, it is recommended to harvest larger plots as described under 1. Harvesting the entire plot.

<u>Proceed with steps 5 and 6 as indicated above.</u>

3. SIMPLE HARVESTING METHOD undertaken by farmer

This method can be used when technicians are not able to reach the field, but the project would nevertheless like to obtain some yield estimates that help in obtaining yield figures. The instructions have to be communicated to the farmer who will be undertaking the harvest, and then report the data back to the technician. The technician should provide the farmer with the data sheet ahead of time and discuss the harvesting procedure carefully step-by-step.

<u>Materials needed:</u>

- Measuring tape (ideally > 20 meters)
- Harvesting scythe
- Scale found in the village (that can measure weight of the bags)
- Rice bags
- Materials for threshing and winnowing (what farmers usually use), including mats.

<u>Step 1: Observations before the harvest</u>

- Farmer needs to decide about the size of the plot to be harvested. He/she should first assess the plot and decide either to harvest the entire plot or to harvest part of the plot that is representative of the entire field. This means not to harvest the best or worst part of the field, but a part that represents the average performance of the field.

<u>Step 2: Remove the boundary around the plot</u>

- Farmer should remove approximately 1 meter of the plot boundary. This does not have to be precise, but can be estimated.
- The plot to be harvested should be a simple square.

- Once the plot is delimitated, the square to be harvested needs to be measured with the measuring tape in meters (length x width). Mark the numbers on the data collection sheet.

Step 3: Harvest the plot

- Farmer is harvesting the entire plot and collects all the grain in one location, separate from the rice harvested from the borders.
- Farmers might dry paddy for a few days, before threshing
- Threshing of rice, and fill rice into bags: report on number of bags (with quarter bag precision at least!)

Farmer will therefore report to the technician,

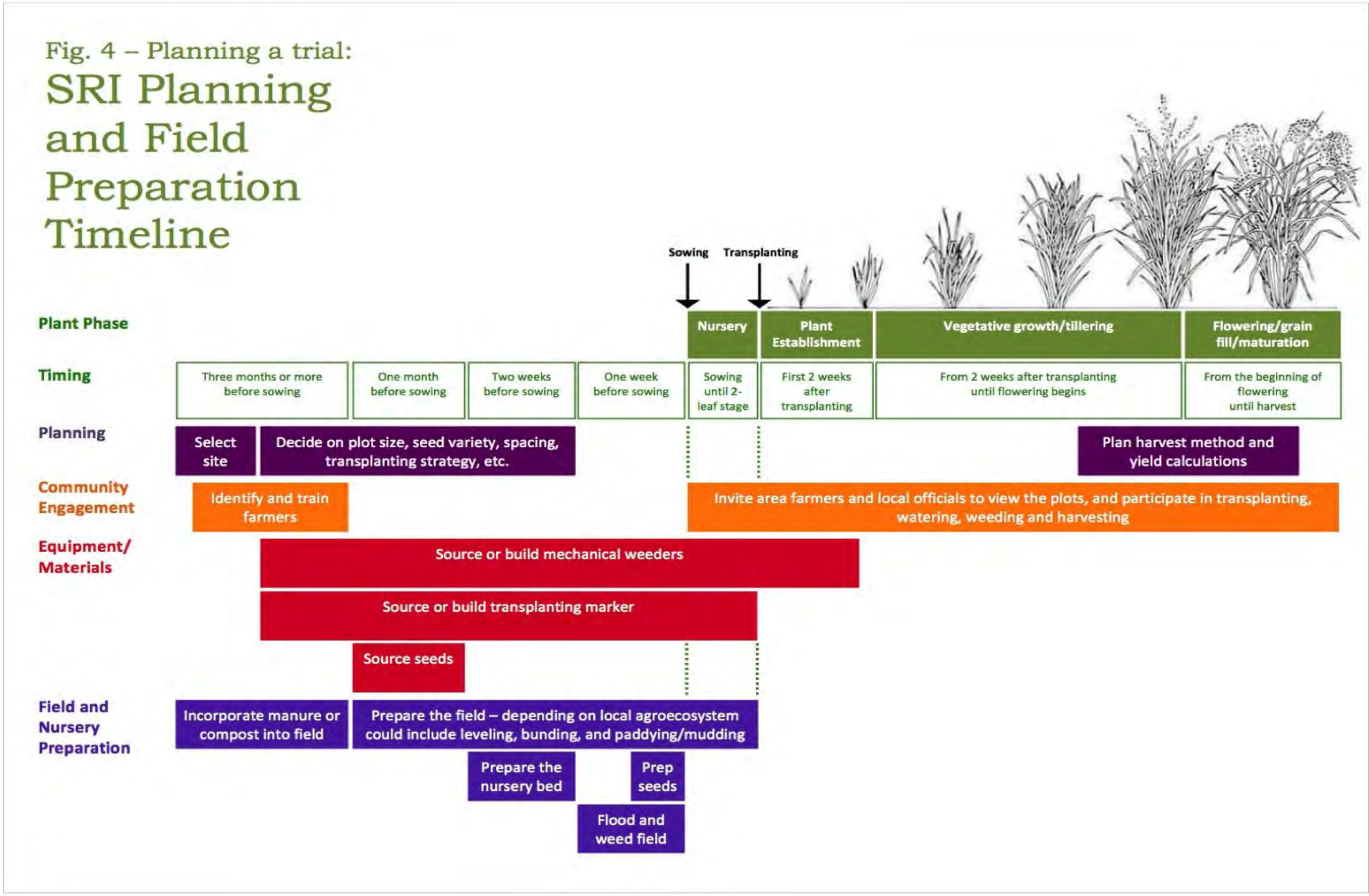
- Length x width (in meters) of the harvested area
- Number of bags (quarter bag precision) harvested from the area.

The technician will be able to calculate the yield as indicated above.

This represents the easiest scenario. It would be ideal if farmers can be trained in undertaking harvesting described as under 1 or 2.

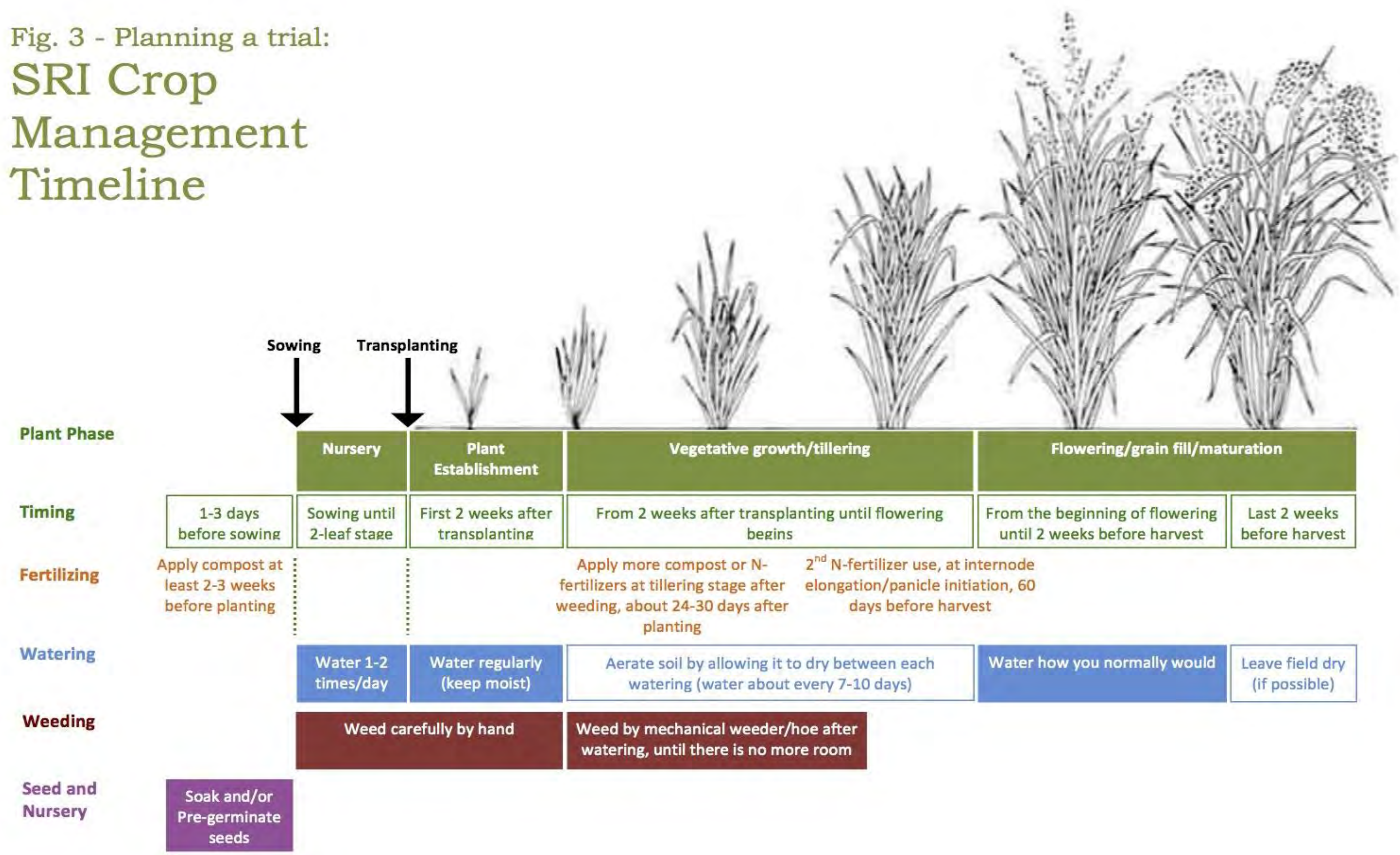
Project staff has to make sure that farmers receive the appropriate data collection sheets.

Annex 6



(Styger and Jenkins, 2014)

Annex 7



(Styger and Jenkins, 2014)