Addressing Climate Change Risks on Water Resources and Food Security in the Dry Zone of Myanmar

Drought Resilient Farming Methods and Technologies in Central Dry Zone of Myanmar

Technical Report

2018

Report verified by NGO/CSO: **Cesvi**

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Report reviewed and endorsed by: **Myo Min Aung (Project Manager)**

Foreword

Enhancing the resilience of agricultural practices in the Central Dry Zone (CDZ)[1] of Myanmar to cope with climate variability and climate change is imperative to the livelihoods and food security of marginal farmers, who are cultivating in this area. Introducing appropriate adaptation strategies will enable farmers to cope with various climate risks, promote efficient use of natural resources to bring sustainability to farm production and stability to their incomes.

Cesvi in partnership with UNDP Myanmar, with funding from Adaptation Fund is implementing the project entitled "Addressing Climate Changes Risk on Water Resources and Food Security in the Dry Zone of Myanmar". The project aims "to reduce the vulnerability of farmers in Myanmar's Dry Zone to increasing drought and rainfall variability, and enhance the capacity of farmers to plan for and respond to future impacts of Climate Change on food security". Among the three main outcomes of the project, the second outcome is the increased diversification and resilience of the most vulnerable rural farmers from climate-induced shocks and stresses.

Outcome 2 comprises the following outputs:

- *Output 2.1: Drought-resilient farming methods introduced to farmers to enhance the resilience of subsistence agriculture in the Dry Zone*
- *Output 2.2: Resilient post-harvest processing and storage systems introduced to reduce climate- induced post-harvest losses (droughts and floods)*

Consistent with the community-based adaptation strategies of the project, concrete investment activities to be implemented under Outcome 2 were preceded by participatory community-based Training Need Assessment (TNA) and Participatory Rural Appraisal (PRA) organized by Cesvi.

Output 2.1 promotes climate resilient farming methods in drought-prone farm land. The portfolio of activities includes improvement of drought resilient crop varieties[2] from government research farm to village level seed farm, through seed multiplication activity; demonstration plots for optimizing plant population by improving crop diversification and intensification to improve income through increase crop yield; climate change adaptation measures such as Alternate Wetting and Drying (AWD) practice; establishment of perennial tree plantation associated with annual crops; drip irrigation demonstration; climate resilient rice varieties selection. It also includes training activities through various methodologies, such as capacity building for local farmers through climate resilient farming method training; farmer field school (FFS) of dry land farming system; and field days on demonstration plot.

Implemented simultaneously, *Output 2.2* focuses on the promotion of climate-resilient post-harvest crop processing and storage to reduce increasing harvest losses. During the harvesting and post-harvesting stages, extreme weather, erratic rainfall, shortage of labor and low quality storage systems are leading to deterioration and collapse of harvested grain. Locally made thresher provision and improved community-managed storage facilities allow both better harvesting and storage. In this regard, threshers and seed storage facilities were delivered to suitable villages after participatory post-harvest assessment and formation of user groups.

In UNDP-AF project, Cesvi is implementing a portfolio of activities, which jointly contribute to opening up opportunities for horizontal and vertical diffusion of the successful farmers' experience,

[1] Or Dry Zone (DZ)

[2] For common DZ crops such as rice, pigeon pea, groundnut.

also thanks to the organization of farmer field day events, favoring the meeting and knowledge sharing among the targeted communities.

This publication documents the climate resilient practices and technologies that were tested in the farmer's fields during the first year of implementation.
Cesvi is appreciating all beneficiaries for their excellent field work and for using climate change resilient and adaptation practices (both farming and post-harvest processing). Their implementation is the ground for the present project "Technical Report".

An update of the current Report will be produced at the end of the project in 2019, adding the analysis of 2018 data and reflecting results, lessons learnt and recommendations referred to the entire life of the project.

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Introduction

Figure 1: Map of Myanmar and its Central Dry Zone

Myanmar's climate is changing while climate variability is already affecting communities and socio-economic sectors in the Country. Climate change impacts are already observable and there is broad scientific consensus that further changes will occur. Among the regions of Myanmar, the Central Dry Zone is one of the most climate sensitive and natural resources poor. This diverse zone includes the southern part of Sagaing Region, the western and two middle part of Mandalay Region and most parts of Magway Region. Across the Dry Zone, water is scarce and the following threats are noted: drought, including dry spells, vegetative cover degradation, severe soil erosion through landslides in farm land.

The monsoon rain is bimodal, with uncertain and scattered patters and regular dry spells during monsoon season from June to October. The farm land is composed mainly by sand and sandy loan with low fertility. As mentioned, it is vulnerable to drought, bimodal rain and severe erosion. The effects are amplified by erratic rain in late monsoon and strong winds in summer season. Farmers need to increase their resilience to changing climate in order to sustain crop production and farm income.

Within Cesvi/UNDP-Adaptation Fund project, technology transfer in drought resilient agriculture is aiming at enhancing farm productivity, capacity building of farmers and reducing vulnerability. In 2017, Cesvi implemented drought resilient farming activities with the aim of supporting the building of resilient capacity of marginal farmers and the introduction of resilient post-harvest infrastructures. Technology and resilient practices can ensure adaptation gains and immediately benefit to farmers' communities along with introduction of drought resilient, short duration, heat tolerance, pest/disease resistant, early morning flowering crop varieties.

Participatory on-farm demonstration (advance intercropping, mix cropping of crop combination per unit of land, establishment of drought resilient perennial tree combined with annual crop) also contributes to enable farmers facing climate variability, while giving access to continuous and long-term income and protecting from market inflation. Innovative water saving technology and irrigation practices promote fresh water saving and possible reduction on Green House Gas (GHG) emissions.

Throughout the project implementation period, knowledge dissemination and collaboration on effectiveness of improved seed varieties were facilitated by Cesvi, Department of Agriculture (DoA), and Department of Agricultural Research (DAR); rice varietal selection was performed with Yezin Agriculture University (YAU) in targeted five regions of Mandalay, Magway and Sagaing Regions.

This Technical Report looks back at all tested practices and documents the essential components of the first year of implementation. It includes technical points of resilient practices, captures lessons learnt on the effectiveness of resilient agriculture practices, success stories and recommendations on scaling up for the second year.

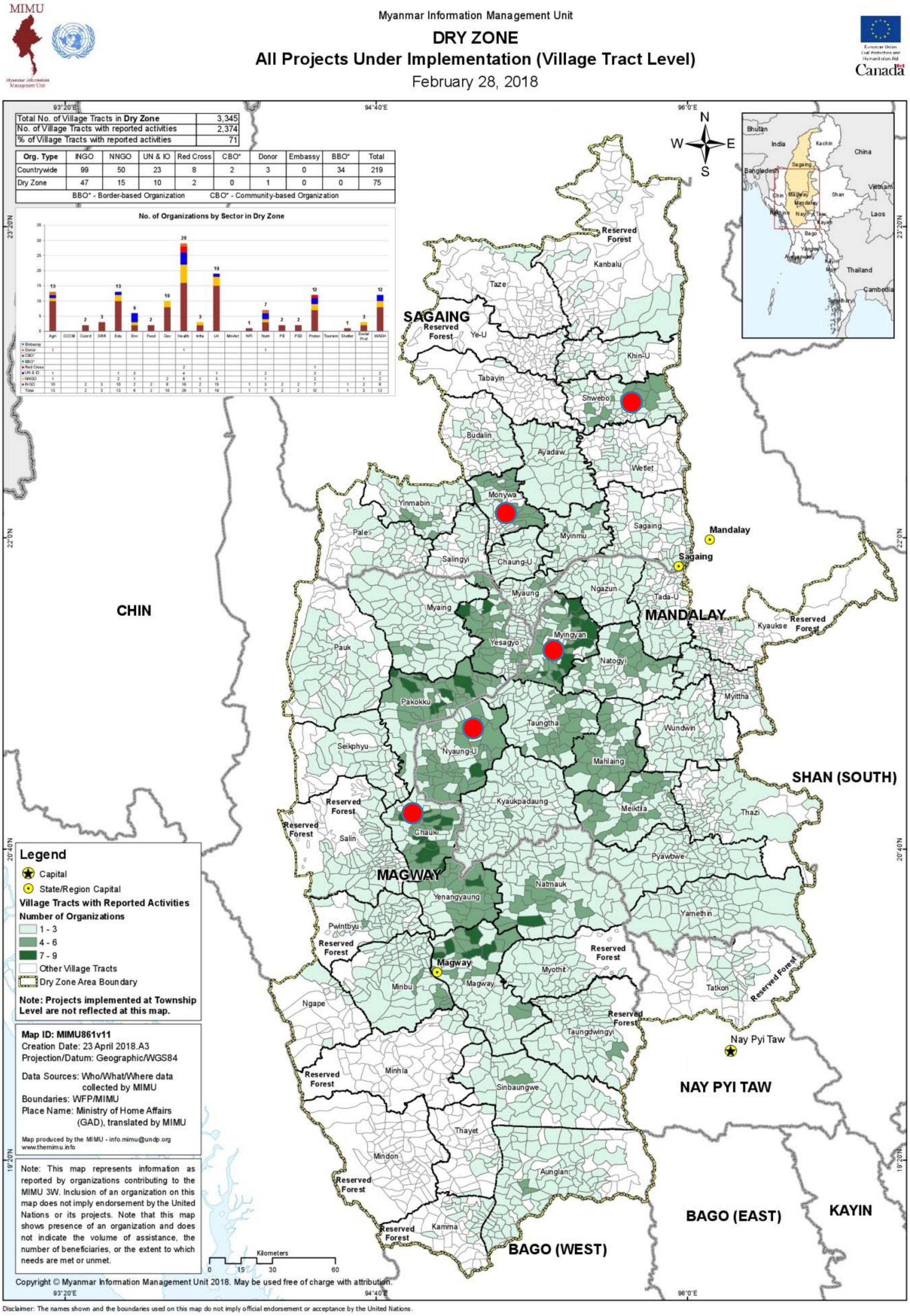

Figure 2 Map of Dry Zone and five Townships of project intervention

Drought Resilient Agricultural Practices #1

Introduce drought tolerant rice variety in rain-fed situation

Climate vulnerability

Drought and water shortage

Existing practice

In the central dry zone (CDZ) of Myanmar, water shortage and irrigation are key constraints in rice cultivation. Although rice can be produced two to three times a year, the majority of rice production in CDZ is limited to the wet season because of the limited water accessibility during the dry season. With limited irrigation, farmers have to leave their land idle during the dry season. Insufficient water is one important reason for low productivity.

Drought can adversely affect rice productivity at different times during the production cycle, since in CDZ, drought can occur at different stages of the cropping season (early/late, for each season). When drought occurs early in the cropping season, it causes a delay in rice transplanting and subsequently yields losses. It also increases the probability of late season yield loss from a delay in flowering. Yield loss could also result from late-season drought, which develops at the end of the wet season before crop maturation and is considered as more severe than early-season drought. Drought caused by climate change is expected to continue in the future and will have a significant impact on agriculture. Based on last 10 years rainfall pattern, CDZ is regularly experiencing severe drought in June, July and August.

Resilience Practice and Technology

The development of drought-tolerant rice varieties will not only alleviate poverty, but also will contribute to improved food security for marginal households. The research activities implemented in DAR Farm includes production of heat tolerant varieties, drought-tolerant varieties and salt-tolerant varieties.

For drought-prone areas, DAR released drought-tolerant varieties (*Yeanaelo-3* and *Yeanaelo-4*). Despite several released varieties, not all of them have been well-accepted by the farmers, mainly due to the superiority of some traits of the existing varieties, as explained in the "Results and Discussion" paragraph below. To introduce the farmers with those varieties and to enhance their adoption by farmers, the project implemented rice cultivation plots with *Yeanaelo-4* variety.

Materials and Methods

As part of participatory demonstration plot activity, adoption of drought-tolerant rice variety was implemented in Myingyan and Shwebo Townships under rain-fed condition. The average yields from local *Manawthukha* and *Yeanaelo-4* varieties were compared.

Results and discussion

Implementation of demonstration plot with drought-tolerant rice variety

Despite the availability of recommended rice varieties released from DAR for rain-fed areas, the adoption of new varieties has only been a partial success, mostly due to lack of key traits important to farmers. It results that DAR should orient the work focusing on farmers' preference, particularly for early maturing and eating quality. The project implemented demonstration on drought-tolerant rice variety in the farmers' field in 5 plots in Myingyan and 1 plot in Shwebo.

Based on collected data from *Yeanaelo-4* variety in the implementing area, the summary of yield comparison with local *Manawthukha* variety is shown in Figure 3. *Yeanaelo-4* gave higher yield than local *Manawthukha* variety. The average yield from *Yeanaelo-4* was 97 baskets per acre (bsk/ac) in Myingyan and 80 bsk/ac in Shwebo. The highest yield 120 bsk/ac was produced in Kan Pauk village from Myingyan.

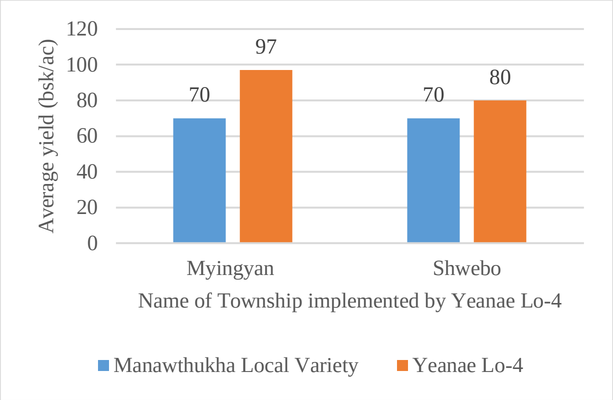

Figure 3: Comparison of average yield per acre

Lessons Learnt

The current market still does not recognize the quality of the *Yeanaelo-4* and often offers a price lower than for *Manawthukha* variety, because of its physical appearance, which is a little bit different from locally accepted varieties. However, the eating quality of *Yeanaelo-4* is better than milling rice after long storage than newly harvested rice. According to the survey from key farmers, it was found that the yield increase was positively valued by household consumption and it is likely to increase the probability of cultivating *Yeanaelo-4* variety.

Success story

U Kyaw Wa from Kan Pauk village is the key farmer of one of the demonstration plots. He received a basket of drought resilient paddy seeds and the specific training.

According to the technical guidelines of the training, U Kyaw Wa grew one acre of paddy demonstration plot. During the growing period, extension staff from DoA and technical specialist from Cesvi visited the field to provide technical assistance. Moreover, 20 farmers visited the field during the farmer field day, organized by Cesvi.

*With the new variety, U Kyaw Wa could harvest **120** baskets from one acre of land, obtaining 40 baskets more than with the local variety of Manawthukha, contributing to an improved food security at household level. Farmers from inside and outside the village were impressed by this drought resilient paddy seed, with its high yield and low amount of water required.*

This variety was also appreciated by local traditional rice snack producer due to its sticky condition just after harvesting. U Kyaw Wa will grow the newly introduced variety in the coming monsoon and will distribute the seeds to other interested farmers.

Figure 4: Drought resilient rice field in Kan Pauk village, Myingyan Township

Recommendation for Scaling Up

To increase the farmers' awareness on drought-tolerant varieties and to determine the key factors contributing to the adoption of *Yeanaelo-4,* follow-up practices are crucial, in addition to monitoring the technical performances. Therefore, *Yeanaelo-4* variety should be included in the participatory varietal selection program, which will be implemented in Shwebo and Myingyan Township.

The adoption of the new variety is expected to be directly related to its cooking quality, as rice is one of the major consumed foods in Country, and to the expected higher yield.

Drought Resilient Agricultural Practices #2

Improve crop nutrition management in rice to improve rice productivity

Climate vulnerability

High temperature
Salinity

Existing Practices

Rice production systems of the region have over recent years become increasingly threatened by the effects of climate change. Wet land rice fields are an important source of methane and they also account for the global anthropogenic methane annually produced. Emission of methane from rice fields is estimated to increase at an average rate of 1.1 % per year over the next 30 years[3]. In central dry zone of Myanmar, problems with salt concentrations in the soils are also important. Therefore most of the farmers in Shwebo Township used to apply soil amendment (gypsum) to help leach salt from the soil.

Resilience Practice and Technology

To elucidate the impact of sulfate availability on methane emission, field experiment with gypsum application were carried out in Philippine rice fields[4]. It was found that adding gypsum to a flooded rice field reduced methane emission by 55-70%. Therefore, as one of the mitigation approach to the changing climate, as well as to hasten the removal of soluble salts (e.g., sodium), gypsum application in rice cultivation was implemented.

Materials and Methods

To increase the farmers' adoption of the application of gypsum in the rice field, 4 rice plots were implemented in Shwebo.

Results and Discussion

Implementation of gypsum application in rice field

Four plots were implemented in Nyaung Kan village and Bow Daw Taw village. The amounts of gypsum used were 2 bags/acre. *Shwe Ma Naw* rice variety was used for this application.

The yields from these gypsum application plots were collected and the average yields of rice were compared with that from farmer's rice field without gypsum application. Average yield were higher than that of normal practice in the farmer's field, as shown in figure 5.

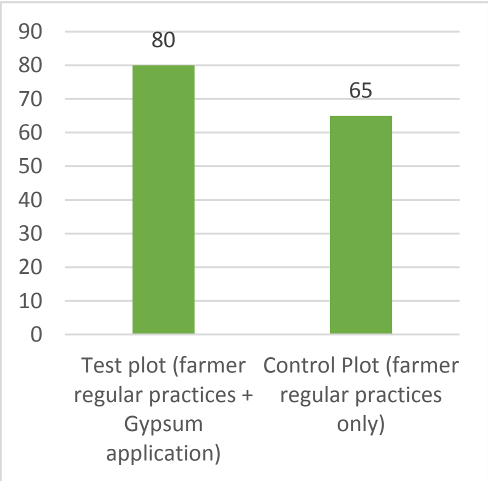

Figure 5 Comparison of average rice yield between test plot and control plot (same rice variety)

[3] Denier van der Gon, H.A.C, 1994. Impact of gypsum application on the methane emission from a wetland rice field, Global Biogeochemical cylces, Vol:8, No.2, Pages 127-134

[4] Neue, H.U. June 1994, Impact of Gypsum application on methane emission from wetland rice field, International Rice Research Institute (IRRI), Los Banos, Philippines.

Lessons Learnt and Success

The original condition of soil in each gypsum application plots was not assessed. Therefore it might be difficult to make clear interpretation on the impact of gypsum on rice production.
The highest yield was obtained from the farmer's (U Thaung Naing) from Boe Daw Taw village, resulting in approximately 120 bsk/ac.

Recommendation for Scaling Up

In order to have clear understanding on gypsum application for rice production together with its correlation with methane gas emission, soil analysis before and after cultivation has to be performed and methane emission should be calculated.

Figure 6: Rice production by using gypsum application in Boe Daw Taw village in Shwebo Township

Drought Resilient Agricultural Practices #3

Climate change adaption measure: Alternate wetting and drying (AWD) practices of water saving irrigation technology in rain-fed rice field

Climate vulnerability

Water scarcity

Existing practice

In the dry zone of Myanmar, rice can be established by direct wet seeding (broadcasting pre-germinated seeds onto wet soil) or direct dry seeding (broadcasting dry seeds onto moist soil) in the main field or nursery seedbed preparation and transplanting to the field. Traditionally, lowland rice is grown in burnt fields, which are continuously flooded from crop establishment to close to harvest. For all rice growing practices, before crop establishment, the main field is prepared under wet conditions. In particular, this wet land preparation consists of soaking, plowing and harrowing to control weeds, to reduce soil permeability and to ease transplanting. After crop establishment, the soil is kept ponded with a 5-10 cm layer of water until 1-2 weeks before harvest. The water balance of a rice field consists of the inflows by irrigation, rainfall and capillary rise, and the outflows by transpiration, evaporation, over bund flow, seepage, and percolation. Of all water outflows, runoff, evaporation, seepage, and percolation are nonproductive water flows and are considered losses from the field. Only transpiration is a productive water flow as it contributes to crop growth and development. Furthermore, flooding techniques involves a high risk of methane emission[5].

In Myingyan and Shwebo rice growing regions, most of the rice fields are irrigated with top sequence system, so called plot-to-plot irrigation practice. Surface drainage and seepage water usually flow into downstream fields and the loss of one field is the gain of another. At the bottom of the top sequence, these flows enter drains or ditches.

Resilience Practice and Technology

With increasing water scarcity, the sustainability, food production and ecosystem service of rice fields are threatened. To develop and disseminate water management practices that can help farmers to cope with water scarcity in irrigated environments, alternate wetting and drying practice was introduced to the farmers in the project area. In alternate wetting and drying (AWD), irrigation water is applied to obtain flooded conditions, a certain number of days after the disappearance of ponded water.

Materials and Methods

Monitoring the water depth in the field using the “field water tube” is a practical way to implement AWD. After an irrigation application, the field water depth will gradually decrease over time. According to the reference, when the water level measured in the tube is 15 cm below the surface of the soil, it is time to irrigate and flood the soil with a depth of around 5 cm[6].

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[5] Methane Emissions from Rice Cultivation: Flooded Rice Fields (Revised 1996 IPCC Guide Lines for National Greenhouse Gas Inventories: Reference Manual)

[6] Kyaw Myaing, Khin Mar Htay, Su Su Win and Ye Tint Tun, 2015. Response of some rice varieties to low water inputs, Myanmar Agricultural Research Journal, No.1, March, 2015

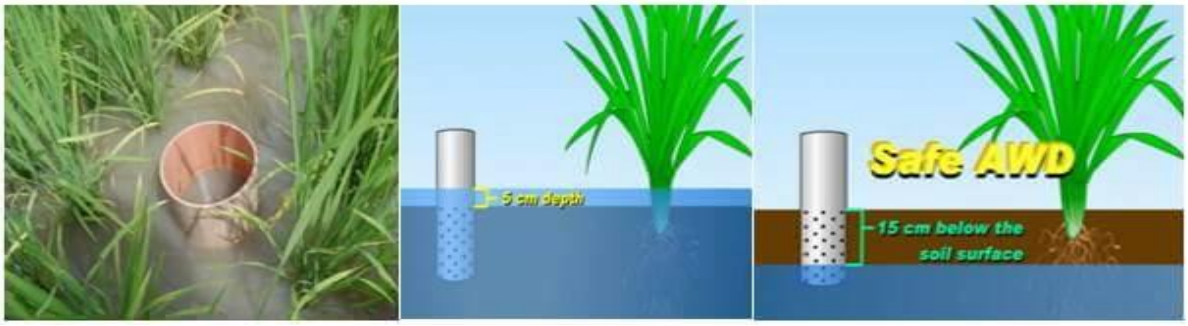


Figure 7: Field control tube installation (left) and illustration of submerged (center) and dried (right) phases

Figure 8: Perforated field water tube

This practice started in the rice field a few days after transplanting as most of the plots implemented by the project used transplanting practice. Around flowering period, from 1 week before flowering to 1 week after peak flowering, the soil was kept with ponded water at 5cm depth to avoid any water stress that would have resulted in potentially severe yield losses. After that, during grain filling and ripening, AWD was applied again. When many weeds were present in the early stages of crop growth, the implementation of AWD was postponed for 2-3 weeks until weeds have been suppressed by the ponded water.

Among five project townships, AWD was implemented in Myingyan, Chauk, Monywa and Shwebo townships, but not in Nyaung U Township as there was no irrigation water available. *Sin Thu Kha* rice variety was used for Myingyan, Chauk and Monywa Townships, while *Shwebo Paw San* rice variety was used in Shwebo Township.

Results and Discussion

Implementation of AWD

60 plots were implemented in Myingyan, Chauk, Monywa and Shwebo Townships within 24 project villages. One and half basket of rice was provided to each beneficiary and total of 67.5 baskets of *Sin Thu Kha* and 22.5 baskets of *Shwebo Paw San* were distributed. 180 field water tubes were also provided by project.

Impact of Technology

To disseminate water saving technology for the farmers, who grow rice regularly in the project area, field day session was implemented during October 2017. According to the information collected from key farmers and field day participants in implementing AWD in each Township, the comparison of yield from AWD and current rice cultivation practice is shown in figure 9.

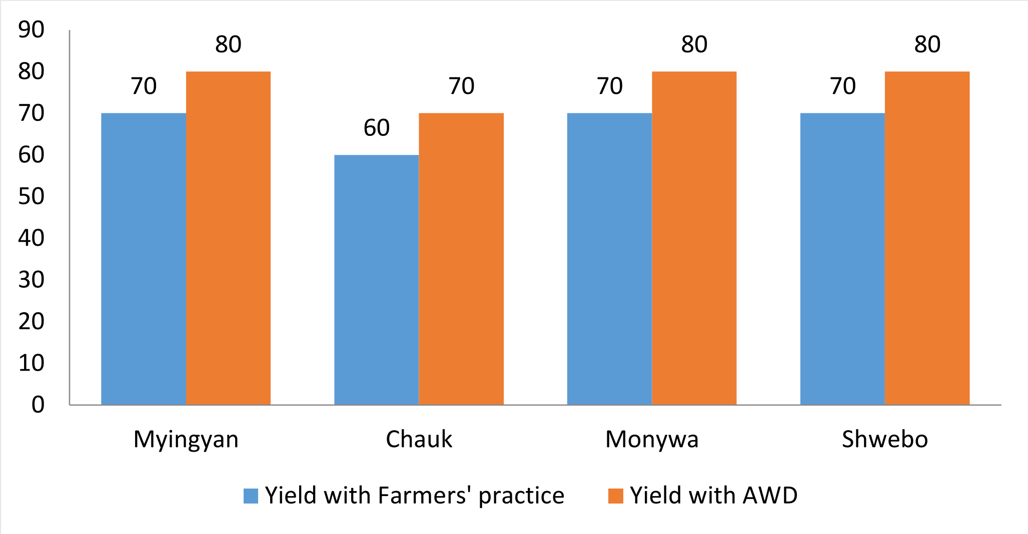


Figure 9: Yield comparison between farmers' practice and AWD

In order to understand farmers' adoption of water saving technology as alternate wetting and drying practice, Cesvi performed focus group discussion in each township. The average yield from AWD practice was increased to 80 bsk/ac, compared to 70 bsk/ac of local practice in Myingyan, Monywa and Shwebo. In Chauk, rice cultivation originally is difficult, because this area is particularly affected by irrigation water shortage. As shown in the table above, the average yield of rice cultivation in Chauk is lower than in the other Townships; however the AWD practice led to an increase from 60 bsk/ac to 70bsk/ac.

In 2017, this practice was implemented during the rainy season and it was therefore not possible to study the effect on water volumes required for this AWD practice.

AWD is the water management practice of the System of Rice Intensification (SRI), an integrated crop management technology developed by the Jesuit priest Father Henri de Laulanie in Madagascar. Although all SRI practices might not be followed in AWD practice, transplanting single seedlings not later than 20 days on seedbed was introduced to the farmers. From this practice, the time to recover after transplanting could be reduced. The seed requirements from farmers practice (3-10 bsk/ac) depending on their cultivation practices were reduced to 1.5 bsk/ ac. In terms of pest and disease management practice, serious problems such as root rot disease and iron toxicity in continuous flooding in farmers' field were significantly reduced in the field with AWD practice.

Lessons Learnt

Concerning the implementation time of AWD practice in 2017, it was found that controlling the irrigation scheme was very difficult because of raining. However, the farmers recognized that the frequency of irrigation could be reduced with AWD practice and they also got more knowledge on the negative impact of continuous flooding in the field. On the other hand, water usage differences between continuous flooding and AWD practice were difficult to compare because of implementation in the rainy season.

Recommendation for Scaling Up

To allow the monitoring of the time and amount of irrigation water in the rice field, in 2018 the implementation will be conducted in the summer rice growing season.

Figure 10: Using AWD practices in rice field in Kan Pauk village, Myingyan Township

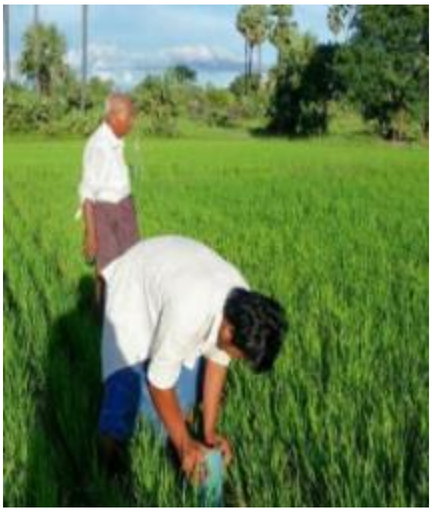


Figure 11: Installation of field water tube

Drought Resilient Agricultural Practices #4

Promote drought resilient crop varieties diffusion through farmer-managed seed multiplication plots

Climate vulnerability

Drought and increased temperature

Pest and diseases

Existing practice

The availability of certified seed varieties for many crops is limited for the farmers in the DZ. This may be the result of a restrictive certification process, low production capacity of public seed multipliers and undeveloped and inadequate private sector import markets. Many farmers from CDZ use the saved grain from the previous harvest, rather than invest in improved varieties from DAR farms. The yield from farmer saved seeds decreases gradually and in general, the farmers in DZ grow long duration local varieties that provide income only one time per year. If drought and lack of rainfall during the flowering period occur, farmers are vulnerable to lose their harvest completely.

Resilience Practice and Technology

Planting good quality seeds is a key component for improving productivity in all agricultural environments. The current yield gap between improved seed and farmer-saved seed is due to varietal yield differences, low seed replacement, poor seed quality and low adoption of good agronomic practices. To increase the adoption of good agronomic practices with good quality seeds, the project implemented farmer managed seed multiplication plots.

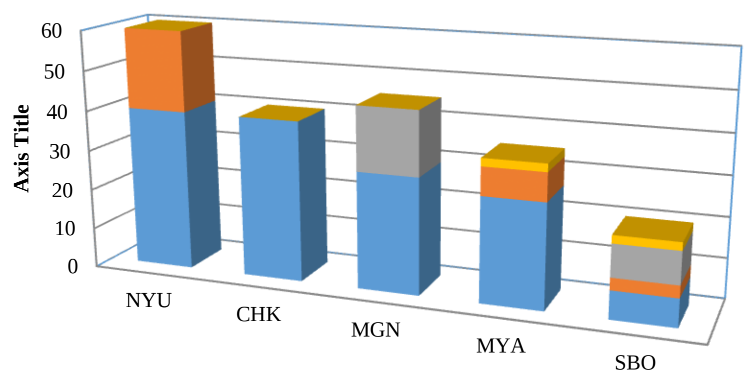
Materials and Methods

200 seed multiplication plots were implemented in five project townships. The quality seeds used in this activity were rice (*Sinthukha*), groundnut (*Sin Padathar-11*), green gram (*Yezin-14*) and Pigeon pea (*Monywa Shwedingar*). The number of plots implemented and the amount of seeds provided are shown in Table 1.

Table 1: List of Townships, number of villages, beneficiaries and amount of seeds provided for the implementation of seed multiplication plots

Sr	Township	Village	Male	Female	Items & Provided Package (bsk)				Estimated Acre
					Rice (bsk)	Groundnut (bsk)	Green gram (bsk)	Pigeon pea (bsk)	
1	Myingyan	23	42	3	24			14.5	45
2	Nyaung U	16	55	5		120		20	60
3	Chauk	14	36	4				20	40
4	Monywa	21	31	4		42	1	13	35
5	Shwebo	12	18	2	12	18	1.5	3	20
	Total	86	182	18	36	180	2.5	70.5	200

The different crops were grown in five project townships, according to the different environmental conditions and preferences of the local farmers. The number of plots for each crop in respective townships is shown in figure 12, while the average yields from each crop is summarized in figure 13.



	NYU	CHK	MGN	MYA	SBO
Greengram	0	0	0	2	2
Paddy	0	0	16	0	8
Groundnut	20	0	0	7	3
Pigeon Pea	40	40	29	26	7

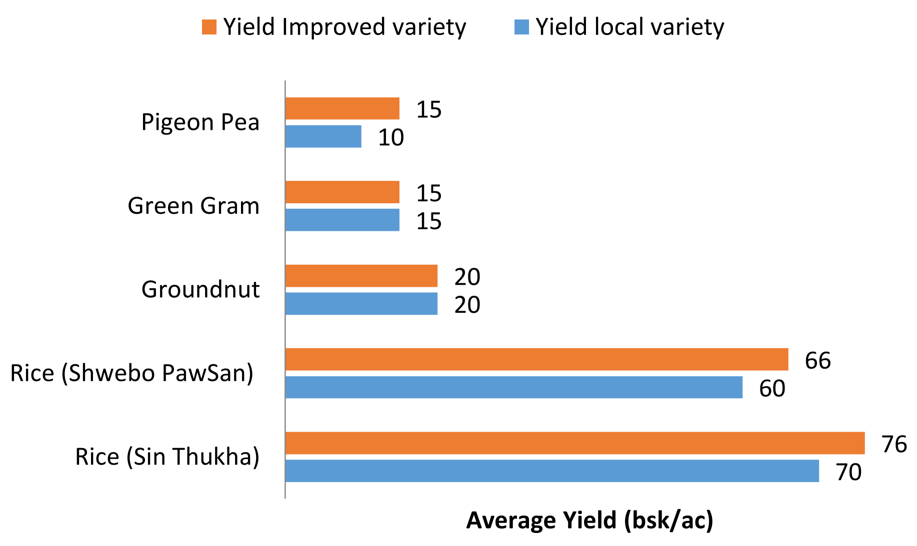
Figure 12: Number of plots of each crop implemented in the respective Township

Impact of Technology

It was found that the average yield from each seed multiplication plots (groundnut, pigeon pea and green gram) were not considerably higher when compared to farmers local variety. It can be assumed that it is because most of the seed multiplication plots were implemented in the pre-monsoon season, which is considered less favorable, due to recurrent drought conditions. For example, in Ywar Thit (S) village the groundnut seed multipliers grow their crop in the pre-monsoon season and there was drought in June and July 2017. Therefore, the crops suffered from drought condition at the peak flowering period. However, the introduced groundnut variety *Sin Padathar-11* could recover from drought and reached a reasonable yield of approximately 20 bsk/ac.

The average yield from rice varieties *Shwebo Paw San* and *Sin Thukha* are considerably higher than local varieties. In terms of technical know-how, farmers enhanced their understanding about the characteristics of each crop from seed multiplication practices. They could learn to increase the spacing of pigeon pea if they grow *Monywa Shwedingar* variety, allowing the reduction of seed requirement, compared to farmers practice.

Figure 13: Comparison of average yields from improved and local varieties



Lessons learnt

According to the survey from key farmers and filed day participants, farmers prefer groundnut and rice for their income, household consumption and for their suitability to changing climate as well. However, some farmers still prefer pigeon pea for its suitability to changing climate, low cost of inputs, less demand for labor and pest and disease management practice, even though challenges are posed by the limited market opportunities.

Recommendation for Scaling Up

To improve farmer managed seed multiplication practice, the needed amount of seeds will be collected back from key farmers, stored as village community fund in the seed storage facilities and transfer to other farmers in the following year.

Figure 15: Seed Multiplication plot of Heat Tolerance Rice cultivar (IR64-HT) in Min Kone Village of Shwebo Township

Figure 14: Seed Multiplication plot of Green Gram short duration (Yezin 10) cultivar in Te Gyi Kone (East) village, Monywa Township

Figure 17: Seed Multiplication plot of Groundnut short duration cultivar (Sinpadathar 11) in Pan Kone Pin village of Nyaung U

Figure 16: Seed Multiplication plot of Heat tolerance rice cultivar (SinThuKha) in Shwe Paw Kyune village of Myingyan Township

Success Story

Daw Tin Nilar Liwn is native of Te Gyi village in Monywa Township. It is one of the most vulnerable villages to changing climate and it is located 10 miles away from Monywa Township. She was selected as a beneficiary of the project during village mass meeting facilitated by Cesvi staff. After that, she received two-day training on seed multiplication, focusing on conceptual knowledge and crop management. The project supported 0.5 basket of green gram seeds (Yezin 14 variety - short duration and drought-tolerance) to be cultivated in the raining season. The seed multiplication plot under 1.00 acre of farm land was planted on 21st May 2017 and had a good crop performance.

Harvesting was done when 80% of the pods had reached maturity stage and three pickings were done at 10 days interval. The last picking was done on 21st August 2017. Daw Tin Nilar Liwn got 15 baskets per one acre, which is a bumper harvest. Thanks to the short duration variety, she can also grow winter onion crop without any delay.

"I sold out 8 baskets of green gram seeds to 16 other farmers, who will grow them in the coming pre-monsoon season and I have earned 240,000 kyats with this selling. The remaining seeds are saved for me and for additional interested farmers as per needs". The total net income during the off-season was 300,000 kyats (total income: 450,000 – cost of production: 150,000). Daw Tin Nilar Lwin added that "drought tolerant, short duration green gram growing in pre-monsoon season is good for extra income, enough to feed my family a whole year, especially during the off-season”.

Drought Resilient Agricultural Practices #4 Research

Selection on new potential rice varieties to adapt climate change through participatory rice varietal selection

Climate Vulnerability

Drought

Increased temperature

Existing Practices

Most of the farmers from dry zone cultivating rice in rain-fed areas are increasingly facing water shortage due to deficit rainfall pattern, declining groundwater table caused by insufficient recharge and high temperature in monsoon season. Farmers from DZ are facing yield reduction, increase of un-filled grain percentage and decrease of annual income. Water shortage at the active tiller stage leads to reduce the number of effective tiller. High temperature at the flowering time also leads to poor fertility rate and high un-filled grain percentage in rice production.

Resilient Practice and Technology

Participatory Rice Variety Selection (PVS) is the rice selection by local farmers on their own farms of finished or near-finished products from plant breeding program. Typically plant breeders develop varieties isolated from active farmers and release varieties that are most productive under ideal conditions; often they are not suitable for marginal farm condition. Therefore, participatory farmers' selection facilitated the development of varieties, which are suitable for marginal soils and farmers' interests. Activity can also effectively be used to identify farmer acceptable varieties and thereby overcome the constraints that cause farmers to grow old and obsolete varieties.

Materials and Methods

The trial on participatory varietal Selection Mother Trial was conducted in Ta Ga Nan Village, Shwebo Township, one of the major rice growing area of the Country, with fifteen lines and one standard check of *Manawthukha* variety. The variety included early maturing, heat tolerant, early morning flowering genotypes and breeding accessions of rice. Early maturing varieties not only reduce the risk of crop losses due to end-of-season drought but can also contribute to reduction of the hunger gap. Heat tolerant varieties can resist extreme temperature during summer time and early morning flowering varieties can escape from heat during flowering and fertilization.

All the tested lines are pre-released varieties (See Table 2). The Rice varietal lines were grown in Randomized Complete Block (RCB) designed with three replications. The length of row is 6m long and 4m wide, with equal-spacing of 20cm between rows and hills.

For the preference analysis, field day was conducted two times: at vegetative growth stage and near harvesting stage to select the most preferable rice lines. Sensory evaluation was also done during the second field day session.

Table 2: Rice varieties included in PVS

Pedigree source	Varietal code	Remarks
YAU 1214-B-B-B-51-2-1	V1	Pre released, Medium duration, High yield
YAU 1215 S-S-S-58-3-1	V2	Pre released, Medium duration, High yield

YAU 1215 S-S-S-16-2-1	V3	Pre released, Medium duration, High yield
YAU 1215 S-S-S-41-1-1	V4	Pre released, Medium duration, High yield
IR64 HT	V5	Pre released, Heat Tolerant
YAU 1215-B-B-B-141-3-1	V6	Pre released, Medium duration, High yield
YAU 1214-B-B-B-1-1-1	V7	Pre released, Medium duration, High yield
YAU 1214-187-1-1-1-1-1	V8	Pre released, Medium duration, High yield
IR64 EMF	V9	Pre released, Early Morning Flowering
YAU 1214-183-3-1-2-1-1	V10	Pre released, Medium duration, High yield
YAU 1215-B-B-B-135-3-1	V11	Pre released, Medium duration, High yield
YAU 1215-53-2-2-2-1-1	V12	Pre released, Medium duration, High yield
YAU 1215-110-1-1-1-1-1	V13	Pre released, Medium duration, High yield
YAU 1215 S-S-S-78-3-1	V14	Pre released, Medium duration, High yield
IR64 EMF+HT	V15	Pre released, Early Morning Flowering and Heat tolerant
Manawthukha	V16	Local check

The objective of the activity was to identify high yielding, adaptable and acceptable rice cultivars under high temperature and drought conditions through farmers' participation. Cooperation agreement between Department of Plant Breeding, Physiology and Ecology, Yezin Agricultural University (YAU), Cesvi and UNDP- AF Project was established.

Results and Discussion

Agronomic performance of improved rice lines

Sixteen improved rice lines were evaluated in Ta Ga Nan village, in Shwebo Township during the dry season in 2017. Significant differences among lines were observed with reference to days to 50% flowering, number of effective tillers per hill, plant height, total number of grains per panicle, 1000 grain weight, panicle length and yield per plant. Among the lines, IR64EMF+HT, IR64HT and IR64EMF register the shortest number of days to 50% flowering; therefore these lines can be selected for short growth duration.

The number of effective tillers per hill ranged from 11.47 to 21.93, with three lines having more than 20 tillers. Compared to the check variety (*Manawthukha*), the lines YAU1215 S-S-S-58-3-1, IR64 EMF, YAU1214-183-3-1-2-1-1, YAU1215-B-B-B-141-3-1, IR64 HT and YAU1215-B-B-B-135-3-1 have a higher number of tillers. .

Plant height ranged from 93.47 cm (IR64 EMF) to 128.89 cm (YAU1214-B-B-B-51-2-1), indicating the possibility of selecting desirable plant height, depending on the uses of straw. The total number of grains per panicle varied from 89.38 to 168.08, with YAU1214-187-1-1-1-1-1, YAU1214-B-B-B-1-1-1, YAU1215 S-S-S-16-2-1 and YAU1215-B-B-B-135-3-1 having a higher number than the check variety (*Manawthukha*). These lines also have high spikelet fertility percentage.

With reference to the 1000 grain weight, all the improved lines were higher than the check variety. Among the 15 improved lines, 11 lines have longer panicle than the check variety. Therefore, selection for higher number of grains per panicle, heavier 1000 grain weight and longer panicle can be performed.

Yield per plant varied from 30.01 gm (YAU1215 S-S-S-78-3-1) to 64.06 gm (YAU1214-183-3-1-2-1-1). Mean yield per plant was 46.14 gm and six improved lines have yield performance higher than that.

Nine improved lines: YAU1214-183-3-1-2-1-1, YAU1215-B-B-B-135-3-1, YAU1215-B-B-B-141-3-1, YAU1214-B-B-B-51-2-1, YAU1215 S-S-S-58-3-1, YAU1215 S-S-S-16-2-1, YAU1214-187-1-1-1-1-1, IR64EMF, YAU1215 S-S-S-41-1-1 give the higher yield per plant than check variety (*Manawthukha*). Therefore, high yielding line can be selected from that trial.

First and second field days event and results

First field day was conducted 60 days after sowing (active tillering stage). Farmers from project- and non-project villages and extension staffs from DoA were invited to visit the trial and rate the performance of varietal lines using a simple technique called "Performance Analysis/Score". Each participant was given two (✓) ballots for the best (the most preferable) varietal lines and other two (✕) ballots for the worst (the least preferable) varietal lines. Researchers facilitated farmers to go through the trial freely and to vote for the best and worst varietal lines. After observing each varietal line, each participant voted both the best and the worst lines, by placing ballots in the envelope placed in front of each line. Finally, researchers from YAU generated a Preference Score for each variety by computing the number of positive votes minus the negative votes and divided by the total number of votes that were done by the participants. Preference Score showed farmers' preference (the best or the worst) at pre-harvest stage and the explanation why the participants liked or disliked the varietal lines.

During the second voting session, varietal lines that had good performance and preference were evaluated by participants. Participants carefully selected the best 3 rice varietal lines as YAU 1215 S-S-S-41-1-1, YAU 1214-183-3-1-2-1-1, and Manawthukha. On the other hand, rice varietal lines YAU1215-53-2-2-2-1-1, YAU1215-S-S-S-16-2-1 and IR64-EMF+HT were voted as the 3 the worst ones. A comparison between the best and the worst selected varietal lines during first and second events is shown in the table below.

Table 3: Voting results of 1st session (60 DAS) and 2nd session (95 DAS)

Best varietal lines (3)		Worst varietal lines (3)	
First voting (60 DAS)	**Second voting (95 DAS)**	**First voting (60 DAS)**	**Second voting (95 DAS)**
YAU 1215 S-S-S-16-2-1	YAU 1215 S-S-S-41-1-1	YAU 1214-B-B-B-51-2-1	YAU1215-53-2-2-2-1-1
YAU 1215-B-B-B-135-3-1	YAU 1214-183-3-1-2-1-1	YAU 1215 S-S-S-41-1-1	YAU1215-S-S-S-16-2-1
Manawthukha	Manawthukha	IR64 EMF	IR64-EMF+HT

**DAS (Days after Sowing)*

Additionally, a comparison of voting scores in positive votes and preference scores for the best and the worst varietal lines during first and second events is mentioned in the following tables.

Table 4: Detailed voting scores in 1st and 2nd Field day sessions

Voting scores of 3 most preferable varietal lines in first and second events		
First Field Day Event		
Varietal line	Positive votes	Preference score
YAU1215 S-S-S-16- 2-1	30	0.130
YAU1215-B-B-B-135-3-1	11	0.046
Manawthukha	32	0.148
Total votes: 106		
Second Field Day Event		
Varietal line	Positive votes	Preference score
YAU1215 S-S-S-41-1-1	59	0.145
YAU1214-183-3-1-2-1-1	31	0.075
Manawthukha	49	0.120
Total votes: 197		

Voting scores of 3 least preferable varietal lines in first and second events		
First Field Day Event		
Varietal line	Negative votes	Preference score
YAU1214-B-B-B-51-2-1	12	-0.130
YAU1215-S-S-S-41-1-1	19	-0.088
IR64 EMF	23	-0.106
Total votes: 110		
Second Field Day Event		
Varietal line	Negative votes	Preference score
YAU1215-53-2-2-2-1-1	28	-0.070
YAU1215-S-S-S-16-2-1	27	-0.068
IR64 EMF+HT	25	-0.060
Total votes: 200		

YAU 1215 S-S-S-16-2-1 was the best varietal line in first voting buut it became the worst one in second voting. Likewise participants voted YAU 1215 S-S-S-41-1-1 as the worst varietal line in first voting and it became the best one in the second voting session. Local check variety, Manawthukha, has consistently outperformed during the entire crop season. On the other hand, varietal line which have significant characteristics of Early Morning Flowering (EMF) and both early flowering (EMF) and Heat Tolerance (HT) traits were identified as the worst ones. Farmers' preference still focuses on the local and known variety. Among the factors that contribute to farmers' resistance to change the preferred variety, concerns about acceptability in the local market play a major role.

Results: Sensory Evaluation

Sensory evaluation is a useful tool for evaluating the cooking and eating qualities and it was applied to 16 varietal lines tested at Ta Ga Nan village in Shwebo. By doing this evaluation exercise, researchers can identify and understand famers' preference and the acceptability of rice varietal lines based on their cooked rice qualities. The reasons for selecting the most-preferred sample are based on characteristics such as color, aroma, tenderness, cohesiveness, purity and elongation. During the event, participants stated their preference and acceptability scores on the individual sensory evaluation form. After the participants finished with the evaluation, YAU researchers collected, reviewed and analyzed data for sensory evaluation. According to its results, the 4 varietal lines which have good eating quality were: YAU1215-S-S-S-78-3-1, YAU1214-B-B-B-51-2-1, YAU1215-S-S-S-41-1-1 and Manawthukha (local check). Varietal lines which have fair eating quality were identified as YAU1215-S-S-S-58-3-1, YAU1215-B-B-B-141-3-1 and IR 64-EMF.

Combined Results of Preference Scores and Sensory Evaluation

The combined results of Preference Scores and Sensory Evaluation in second field day of participatory varietal selection are presented in the table below.

Table 5: Sensory Evaluation result and Preference Scores

Sr.	Code	Varietal line	Sensory Evaluation		Preference Scores	
			Good	Fair	The best	The worst
1	V4	YAU1215-S-S-S-41-1-1	√		√	
2	V10	YAU1214-183-3-1-2-1			√	
3	V16	Manawthukha (Local check)	√		√	
4	V12	YAU1215-53-2-2-2-1-1				√
5	V3	YAU1215-S-S-S-16-2-1				√
6	V15	IR64-EMF+HT				√
7	V14	YAU1215-S-S-S-78-3-1	√			
8	V1	YAU1214-B-B-B-51-2-1	√			
9	V2	YAU1215-S-S-S-58-3-1		√		
10	V6	YAU1215-B-B-B-141-3-1		√		
11	V9	IR64-EMF		√		

Data source: Yezin Agricultural University

Impact of Participatory Rice Variety Selection

The project adopted a PVS (Participatory Variety Selection) method to provide an opportunity for farmers to evaluate climate resilient rice variety lines under researcher management and agro-climatic conditions. According to the results on field performance and sensory evaluation, 4 lines are selected for the baby trials in 2018. These lines are YAU1214-B-B-B-51-2-1, YAU1215-S-S-S-41-1-1, YAU1214-183-3-1-2-1-1 and YAU1215-S-S-S78-3-1. These lines have been multiplied in the rainy season 2017 at the field of YAU. Baby trails will be followed in rain fed area of Shwebo Township with 18 marginal farmers.

Lessons learnt

PVS methodology is allowing farmers' judgment on both objective and subjective parameters to enter the breeding process in the final stages. This can make the breeding process more efficient, delivering better-adapted varieties faster, speeding seed distribution of preferred varieties by informal distribution networks and also feeding back farmer preferences earlier to the national breeding program[7] . Eating quality especially is an important parameter that has caused otherwise suitable varieties to be discarded by farmers.

The material chosen for the PVS trials was not always ideal. The lack of clear-cut differences between some of the varieties included in the PVS made it more difficult for the farmers to choose and rank them. The number of varieties tested should be balanced between what is useful for the breeders and acceptable by the farmers. During the field day, it is needed to attend male and female farmers equally, because the preference or criteria of selection among male and female farmers and researchers are usually different. Farmers had difficulty in visually ranking too many rice lines and may be difficult to evaluate the cooking and eating quality of too many lines.

[7] Virk et al. 2003; Belay et al.2005; Dorward et al. 2007

Cesvi included heat tolerant and heat escape lines in the trial. However, farmers didn't attribute to these characteristics a priority value and didn't choose these lines in the selection process. Cesvi will conduct another cycle of this mother trial at heat and drought prone locations, in Myingyan Township, keeping on using some of the lines from the previous trial and including some drought and salinity tolerant lines. The 'baby' trials will proceed as planned in the three villages of Shwebo Township in 2018.

Recommendation for Scaling-Up

In future evaluations, it would be good to gather from the farmers additional information related to the environment (such as soil type, drought and flood or salinity occurrence) and to increase the locations of testing. This would allow testing interactions between cultivar and environment and ensuring more consideration on meeting farmers' requirements. It is needed to invite male and female farmers equally and give incentive to come to the selection process at active tillering stage and pre-harvest stage (field day).

Figure 18: Climate resilient rice variety selection in Ta Ga Nan village of Shwebo Township collaboration with YAU

Figure 19: New potential rice cultivar was tested in participatory rice selection in Ta Ga Nan village of Shwebo collaboration with YAU

Figure 20: New potential rice cultivar (Early Morning Flowering var.) was tested in Participatory rice selection in Ta Ga Nan village of Shwebo Township

Figure 21: Women farmer are participating on participatory rice varietal selection in Ta Gan Nan village of Shwebo Township

Drought Resilient Agricultural Practices #5

Establishment of intercropping plot with annual dry land crop and perennial tree (Thanakha, Mango, Guava and etc.) to tackle climate variability

Climate Vulnerability

Drought and Erratic rainfall pattern

Existing Practices

The traditional cropping systems in project targeted area such as Nyaung U, Myingyan, Chauk Townships are mono-cropping system, where groundnut or pigeon pea are grown as sole crops, and intercropping system, where groundnut and pigeon pea are grown simultaneously in the same field. Farmers are also growing perennial tree such as *Thanakha*, Mango and *Indian Jujubee* with mono-cropping system in Monywa and Myingyan Townships. Farmers refuse intercropping with annual crop such as groundnut and perennial tree such as *Thanakha*, Mango and other kinds of fruit and perennial trees, due to shade effect and concern on reduced yield of annual crops, due to customary beliefs or lack of knowledge. However, most of the farmers from Myaing Township, which is a non-project Township in the Dry Zone, are using groundnut and perennial tree of *Thanakha* as systematic intercropping, mainly due to the increased demand of *Thanakha* on the local market and the spacing of the *Thanakha* plots being wide enough to allow growing annual crops, such as groundnut. .

Resilient Practice and Technology

The Project supported establishment of perennial tree plantation combined with annual crops, with systematic rows, which act on three main components: 1) *natural resource management,* particularly soil and water, 2) *promotion of agro-forestry* (or crop association) to improve farmers' resilience and households' income during off-season of annual crops and 3) *extend growth for efficient drought resistant trees* in the farm lands. Farmers can grow groundnut, green gram in pre and mid monsoon between the rows of *Thanakha* or Mango. *Thanakha* tolerates heat and drought and can provide good income to farmers. Mango (*Sein Tha Lone* variety) is also considered as a cash crop in Myanmar.

Materials and Methods

Project provided *Thanakha* saplings to establish *Thanakha* based dry land farming system and Mango, Guava, Sterculia trees to establish fruit tree based dry land farming system. Farmers can grow annual crop such as sesame, groundnut, green gram and chickpea between the rows of perennial trees.

Thanakha and annual intercropping plot

Before the implementation, project supported technical hand-on training of *Thanakha* growing for selected beneficiaries. Each beneficiary (60 total), together with training, received 700 *Thanakha* seedlings in Nyaung U, Myingyan and Chauk Townships.

Fruit tree and annual intercropping plot

Before the implementation, technical hand-on training sessions of fruit tree growing were provided. After training, each beneficiary received fruit tree sapling; quality saplings were collected from private farms and government Horticultural department's farm under DoA. 32 saplings of mango (16 saplings were grafted and 16 saplings were grown by seed), 20 saplings of wild almond, 10 saplings of jujube and 10 saplings of guava have been supported to each beneficiary and would be used in 0.5 acre of land owned by the targeted farmers. 152 beneficiaries (136 male farmers and 17 female farmers) received perennial tree saplings.

Results and Discussion

Impact of Intercropping with annual crop and perennial trees

Intercropping fruit trees with annual crop on farms is a sustainability-enhancing practice that combines best attributes of forestry and agriculture. Its impact can be assessed in the medium-long term (5-15 years). Mango is one of the most important and widely cultivated fruit tree in dry zone. The project provided *Sein Ta Lone* mango plants, which could start bearing 4 to 5 years after planting and reach their maximum bearing capacity within 12-15 years after planting. The inter row space remains underutilized in the early growing period.

Location specific and market driven crops can be grown as intercrops and filler crops, allowing growing more than one crop, utilizing efficiently space and natural resources. The intercrops not only generate extra income but also help to control soil erosion, through ground coverage and improve the physio-chemical properties of the soil. According to the survey to key farmers, it was found that the fruit tree beneficiaries cultivated groundnut, green gram, sweet corn and sorghum in the inter rows space of fruit trees, depending on their soil condition.

Since *Thanakha* is a tree crop with wide spacing, in the plantation plots other seasonal field crops such as sesame, green gram, cow pea and maize are encouraged to be cultivated between the rows for the first 3 to 4 years, before *Thanakha* trees are fully grown. All *Thanakha* beneficiaries in the project villages adopted this cropping system.

Figure 22: Perennial fruit tree plot for marginal farmer to get long-term income in Htan Taw Gyi village of Myingyan Township

Recommendation for scaling up

Thanakha had long been used as a traditional cosmetic by Myanmar people and recently found ways to foreign markets. The number of *Thanakha* plantation plots should be increased in 2018. It is also suitable for cultivation in high risk-rain fed conditions. It is also suggested that the trees that grow in the upland area of the dry zone are more fragrant than those produced in other areas. On the other hand it is believed that if they were produced in fertile soil, their quality would be low with a thin bark and large trunk. Therefore, marginal farmers with low fertile soils were encouraged to be supported. However, for daily foods and basic household needs, seasonal cash crops will be cultivated in every *Thanakha* and fruit tree plantation plots.

Figure 23: Perennial drought resistant tree (Thanakha) for marginal farmer to get long term income in Chin Myint Kyin village in Myingyan Township

Drought Resilient Agricultural Practices #6

Short duration Pigeon pea variety for late sowing

Climate Vulnerability

Drought

Existing Practices

Pulses and oil seed crops are predominantly grown under rain fed condition. Changes of rainfall are leading to more frequent drought situation during early and mid of monsoon. This trend is provoking the reduction of productivity of specific crops grown under constrained resource and reduced resilience on livelihoods of poor farmers. The existing variety of pigeon pea is medium/long duration variety, from 180 days to over 200 days. The situation of local cultivars has no flexibility for time of sowing, since they have to be grown in early monsoon season, according to their long age. Often crop failures are experienced either due to rainfall extremes or disease occurrence during the flowering times.

Resilient Practice and Technology

Improved short duration pigeon pea variety (*Yezin 10*) was introduced under farmer field school in dry land farming activity to increase flexibility and to ease adjustments for crop growing time according to the drought condition in early monsoon. This cycle was 100 days long and short duration variety can be replanted even in the mid of monsoon according to rainfall, to improve the farmers' resilience for drought prone farm.

Materials and Methods

Introduction of short duration variety of pigeon pea were tested in plots of 11 villages in Chauk Township and 3 villages of Monywa Township under farmer field school activity, with the aim of allowing the farmers replanting in drought prone area, when crops get damaged due to early monsoon period. The project provided seeds to test farmer field school area, to learn about the characteristics of the new variety and its performance.

Results and discussion

Implementation of demonstration plot with drought-tolerant pigeon pea variety

Despite the availability for drought prone dry farm of recommended pigeon pea short duration varieties released from DAR, the adoption of new varieties has had only partial success, to some extent due to lack of traits which are important to farmers. The project needs to further identify the factors affecting the adoption of pigeon pea short duration variety of *Yezin 10* by focusing on farmers' preferences, particularly for early maturing varieties.

Based on collected data from pigeon pea (*Yezin 10*) in the implementing area of Chauk and Monywa Townshisps, average of 3 baskets in 11 villages of Chauk Township and average of 5 baskets in 10 villages in Monywa and in 5 villages of Shwebo have been harvested.

Lessons Learnt

The current market still does not recognize the quality of the *Yezin 10* short duration pigeon pea and often suppresses its price because of its physical appearance, which is a little bit different from locally marketable variety of *Monywa Shwe Dingar*.

Recommendation for scaling up

Newly introduced short duration variety was useful for farmers when delayed planting and late sowing condition occurred, due to different crisis, such as drought and high temperature in early monsoon season. Even though it is acknowledged that farmers prefer *Monywa Shwe Dingar* variety, due to their knowledge of it and the market viability, it is recommended that farmers save *Yezin 10* seeds, improving their resilience to climate change, especially when natural hazards occur. *Yezin 10* variety can protect soil surface and give some productivity, when delay planting and late sowing condition occur. Local Department of Agriculture should contribute to sensitize local private dealers regarding the new variety of pigeon pea. Additionally, private dealers are also facing crisis of pigeon pea export to India; this new pigeon pea variety has the potential to effectively support farmers' coping opportunities in case of drought in pre-monsoon, when the price of pigeon pea increases.

In early monsoon, drought occurs almost every year. As a consequence, pigeon pea gets often damaged or can't ensure satisfactory conditions. With the usage of short duration variety, farmers can grow the pigeon pea also in mid and late monsoon, being able to respond to market demand.

Figure 24: Pigeon pea short duration variety (Yezin 10) plot for late sowing in Wa Ya Kone village in Chauk Township

Figure 25: Pigeon pea short duration variety (Yezin 10) plot for late sowing in Kyauk Kwe village in Monywa Township

Figure 26: Pigeon pea short duration variety (Yezin 10) plot for late sowing in Kyoe Kyar Kan village in Monywa Township

Drought Resilient Agricultural Practices #7

Enhancing resilient through improvement of post-harvest processing by providing locally-made threshers

Climate Vulnerability:

Erratic rainfall during harvest and post-harvest time

Existing Practices

During the harvesting and post harvesting time, unfavorable conditions, such as erratic rain and labor shortages result first in lack of timely labor then in deterioration and collapse of harvested grain. For instance, in Dry Zone normally after the harvesting of paddy, farmers dry their grains in the open field but when the erratic rain comes, they do not manage to collect, store and protect the grains from the rain.

In traditional practices of post-harvest handling and storage, from 3% to 20% of yields are wasted. Existing post-harvest systems include chain harvesting, threshing, drying, storing, processing, product evaluation, packaging, marketing, use and finally establishing/gaining consumer preference.

Unseasonal heavy rains, floods, damp and pests are among the main factors related to climate change impacting crops post-harvesting. It was observed that the majority of villages were affected by unseasonal rainfall and pest for groundnut and pulses, highlighting the potential room for improvement in the post harvesting process.

Resilient Practice and Technology

The focus has been put on the improvement of steps from harvesting to processing. For this purpose, locally made rice and multi-crop threshers have been delivered to the selected villages after forming Users' Groups to effectively handle management and maintenance of the machines in the long term. Due to the delivered threshers, harvested crop could be handled and stored with minimum loss and maximum efficiency.

Materials and Methods

Post-harvest assessment in 180 villages in 5 project Townships was performed in January 2017 to get a clear understanding on the local crop losses and analyzing the specific impacts of climate stress. Cesvi, DoA and GAD then selected 127 villages for thresher support according to the crop loss results. After village selection and preparation of users' groups (Thresher User Group – TUG), Cesvi organized thresher delivery ceremony in every Township in collaboration with regional, district and township level of DoA, GAD, DZGD and Members of Parliament. After thresher delivery, specific training sessions for operation and maintenance for TUG members (mainly key person of TUG such as chairperson, operator and bookkeeper) were organized.

Results and Discussion

Impact of threshers' provision to user groups

From December 2017 to February 2018, Cesvi teams performed one survey trip to 127 Thresher User Groups (105 multi-crop threshers and 20 rice threshers) in five targeted Townships. According to the survey results, 70% of rice threshers (14 rice threshers/20 total rice threshers) are performing in the villages. 290 marginal farmers (246 male headed HH and 44 female headed HH) benefited from them and treated 38,589 baskets of rice with project provided rice threshers. On the other hand, 57% of multi-crop threshers (61 out of 107 total multi crop threshers) are performing in communities, benefitting 862 marginal farmers (567 male headed HH and 295 female headed HH). 12,951 baskets of crops (3,216 baskets of chickpea, 292 baskets of sorghum, 8,105 baskets of pigeon pea, 398 baskets of groundnut, 808 baskets of horse gram and 132 baskets of green gram) were treated by project provided threshers.

Success story

Sar Khar village is located in the Sar Khar village tract in Myingyan Township. There are 329 total households in this village and 100 of them are woman headed households. 60% of farmers are marginal farmers (owning less than 6.5 acres), while 40% own more than 6.5.

In order to get to know deeply the livelihoods of the farmers and to optimize harvest and post-harvest processing and storage techniques, Cesvi performed an assessment on each step of existing post-harvest systems, analyzing climate-related impacts and resilience.

2,830 acres of agricultural land were found in this village, growing groundnut, pigeon pea in monsoon and chickpea in winter season. Four multi-crop threshers were owned by 4 rich farmers, while marginal farmers used traditional post-harvest processing methods of threshing, such as beating and animal treading, or they rent threshers from the other farmers. According to the post-harvest assessment results, some harvest was getting lost, mainly because marginal farmers could not afford the labor or the threshing machine rental costs. Community-managed thresher had the potential to be a solution for vulnerable farmers.

The project supported the multi-crop thresher and the engine has now been set up on bullock cart, which was procured through the contributions of user group, organized by 80 marginal farmers. During the last chickpea and pigeon pea harvesting period, almost 997 baskets were treated by project provided thresher, crop losses have been reduced up to 1% and Thresher User Group charged 5,000 MMK per hour.

U Maung Myint, Patron of Thresher User Group, said: "In 25 baskets of chickpea crop, 1.25 baskets were lost by waiting the labor for threshing, winnowing and cleaning. Now, farmers can save this loss by using project provided thresher. Thresher User Group Committee also got 155,000 MMK of common funds."

Thanks to the project, the farmers of Sar Khar village could solve the threshing problem in post-harvest period, save money, reduce crop loss and smooth their work.

Figure 27: Multi-crop thresher user farmer group is using thresher for Pigeon pea crop in Tu Ywin Bo village of Myingyan Township

Lessons Learnt

- The limitation of multi-crop thresher to thresh the groundnut hinders the performance of threshers.
- Even after modifying multi-crop thresher to thresh groundnut as well as pulses, some communities have difficulties in contributing the required funds to complete the installation, as they have already contributed bullock card and certain materials in setting up the machine.
- Multi-crop threshers were designed to thresh many kinds of pulses, but it is still needed to modify the number of threshing tooth inside the machine (as for example, some of the teeth were needed to remove from the machine for threshing chickpea and pigeon pea not to break down the seeds).
- In some villages provided with rice thresher, farmers faced difficulties with irrigation to their rice field in the previous season and there was no rice to be harvested.
- The usefulness of Multi-crop Threshers was impacted by sudden changes of pulses market price in 2017.

Recommendation for scaling up

Project should provide groundnut seeder, groundnut harvester and groundnut thresher for the farmers group from Nyaung U, Myingyan, Chauk and Monywa Townships, based on the preference expressed by the farmers of cultivating groundnut instead of pigeon pea in the coming season. Due to the labor shortage, groundnut seeder is supported to farmers in order to ensure timely plantation and capture of the rain water, within a short time. Harvester and thresher are different functions and both machines will contribute to positively affect local farmers in the harvest and post-harvest phases.

Famers from Nyaung U and Chauk Townships have motivation to improve project provided threshers, not only the multi-crop ones but also the groundnut threshers, by changing some parts of inner materials.

Figure 28: Rice Thresher user farmer is using rice threshing in Shwe Paw Kyune village of Myingyan Township

Figure 29: Women farmer is using thresher for groundnut threshing in Mon Taing village of Nyaung U Township

Drought Resilient Agricultural Practices #8

Economic analysis on participatory demonstration for crop diversification and intensification for resilience to climate variability

Climate Vulnerability

Drought
Increased temperature
Soil erosion

Existing Practices

Intercropping is the agricultural practice of cultivating two or more crops in the same space at the same time. In intercropping, there is one main crop and one or more added crops, with the main crop being of primary importance for economic or food production reasons. For large-scale farmers, who plant and harvest one crop on the same piece of land by using machinery and inorganic fertilizers, intensive mono-cropping is very profitable, ensuring high quantity of harvested crop. However, for small scale farmers, who often do not have easy access to market and grow enough food only to sustain themselves and their families, it is recognized that intercropping is one good way of ensuring their livelihood. Additionally, at present land degradation and severe soil erosions are common features in most part of the dry zone[8]. In order to protect the soil from desiccation and erosion, intercropping provides year-round ground cover or at least for a longer period than mono-cropping. By growing more than one crop simultaneously, farmers can maximize water use efficiency, maintain soil fertility and minimize soil erosion, which are serious drawbacks of mono-cropping.

The lower incomes from agricultural work have threatened farmers' livelihood security and forced them to depend on different income sources for their survival. A lot of farmers in the dry zone area also fall into the debt trap and certain amount of farmers degrade and become landless because of accelerating environmental threats and socio-economic forces.[9] Unlike other parts of Myanmar, the dry zone is naturally prone to natural disasters and hinders to get access to natural resources such as water, forest and soil. In order to help the marginal farmers to sustainably manage harsh environments and to meet their subsistence needs, without depending on mechanization, chemical fertilizers, pesticides or other technologies of modern agricultural science, the project developed and inherited from previous experiences complex farming systems in the form of polycultures that were well adapted to the local conditions.

Materials and Methods

To better understand how intercrops function and to develop intercropping systems that are compatible with current farming systems in the project area, participatory demonstration plots with different intercropping practices were implemented with 180 beneficiaries in 74 villages. The following specific objectives can be pointed out:

- To identify the better intercropping practice for the farmers in the central dry zone of Myanmar;

[8] Swe, K.L. (2005), Temporary windbreak effect on soil-water conservation and growth and yield of certain crops in the Dry Zone, Myanmar. *Proceeding of the Fourth Agricultural Research Conference in Commemoration of the Ruby Jubilee of Yezin Agricultural University, 34-41.*

[9] Kyi, K.M. (2012), Farmer vulnerability amidst climate variability: A Case Study of Dry Zone of Myanmar. ICIRD, 1-11.

- To provide an overall view and evaluation of intercropping practice in central dry zone of Myanmar;
- To summarize the main advantages supported by a number of key examples of cropping patterns;
- To select the most suitable intercropping practice, which is economically beneficial for the farmers in the central dry zone of Myanmar.

Several types of intercropping, all of which vary the temporal and spatial mixture to some degree, have been described in many research papers. However, according to our knowledge, this is the first technical report relating to the farmers preference among several types of intercropping practices in central dry zone of Myanmar. In our program, the type of intercropping is an alternate-row intercropping in which two or more plant species are cultivated in separate alternate rows. In all types of intercropping used in this activity, farmers introduced the practice of sowing a fast-growing crop with a slow-growing crop, so that the first crop is harvested before the second crop starts to mature. However, this type of intercropping did not require any kind of temporal separation such as different planting dates of the component crops and all crops could be grown simultaneously. The following types of demonstration plots were implemented in five project townships:

- Type-1: Drought resistant rice varietal demonstration (*Yae Ah Nei Lo4* variety)
- Type-2: Gypsum application in rice field (*Shwe Ma Naw*)
- Type-3: Groundnut-based cropping system (*Sin Pa Da Thar 11*, and *Monywa Shwe Dingar*)
- Type-4: Pigeon pea + Groundnut + Green gram based cropping system (*Yezin 14*, *Sin Pa Da Thar* 11 and *Monywa Shwe Dingar*)
- Type-5: Pigeon pea-based cropping system (*Monywa Shwedingar*, *Sin Pa Da Thar 11* and *Yezin 14*)
- Type-6: Sesame-based intercropping system (*Sa Mon Nat* and *Monywa Shwe Dingar*)
- Type-7: Pigeon pea + Sorghum-based intercropping system (*Monywa Shwe Dingar* and local variety)

In total, 180 plots were implemented in five project Townships according to the local climatic conditions. Among 7 types of demonstration plots, Type-1 and Type-2 are rice-based cropping systems and thus implemented in rice growing area, Shwebo and Myingyan. Type-5 (pigeon pea + green gram and groundnut) were well distributed in all five project Townships, being about 42% of total plots. It is followed by Type-3 (groundnut-base cropping system) which is 28% of total plots. Type-4 is the third largest number of plots (12%) and is distributed in 4 project Townships, except from Shwebo. Since the local farmers in Monywa have experience in growing pigeon pea with sorghum, Type-7 was implemented in Monywa only.

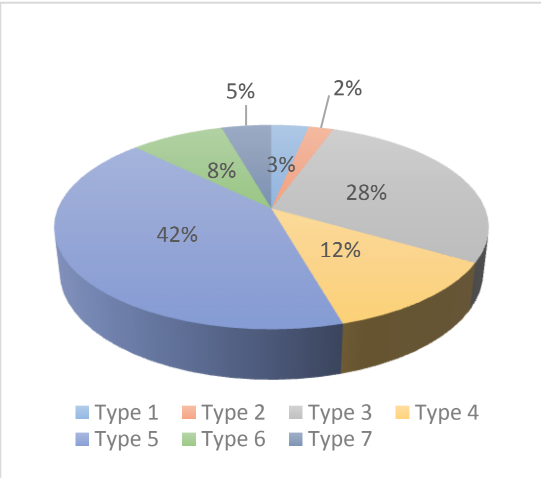


Figure 30: Distribution of demo plot types

The geographical distribution of the implemented participatory demonstration plots is summarized in Table 6.

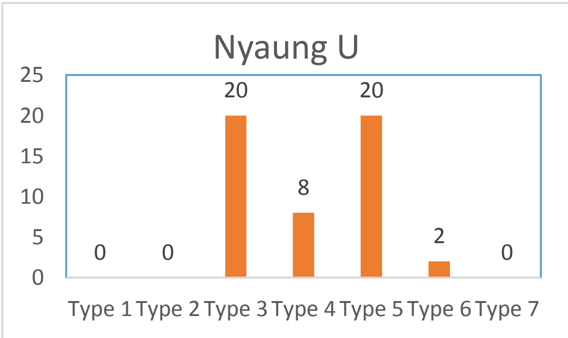
Township	No. of Selected Villages
Nyaung U	17
Chauk	10
Myingyan	17
Monywa	19
Shwebo	11
Total	**74**

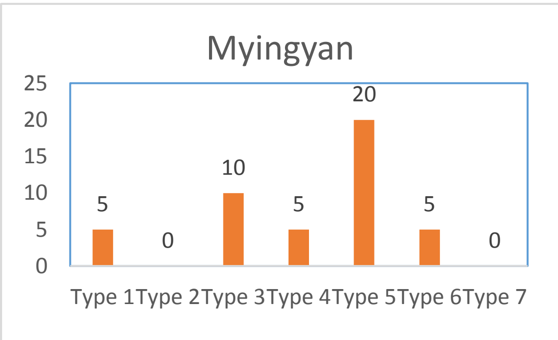
Table 6: Number of villages per Target Township that received the participatory demonstration plots training

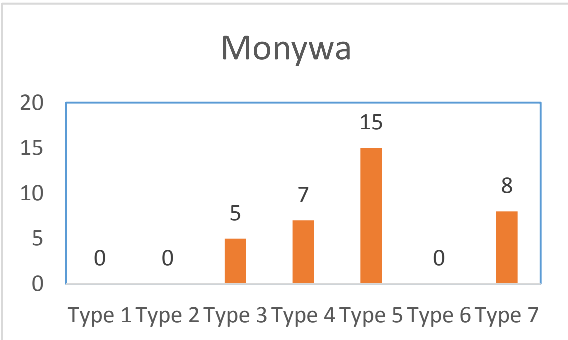
The extension agents of DOA from each Township participated in collecting data at different growth stages including vegetative growth stage, flowering growth stage and harvesting stage. The collected data were:

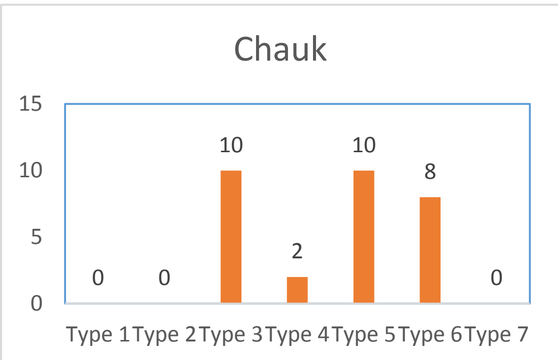
(1) Land preparation;
(2) Manure application and cost of manure;
(3) Cost of cultivation (seed, labor cost for management, fertilizer, cost of inter-cultivation, foliar application, weed/pest/disease management cost and etc.);
(4) Cost of harvesting;
(5) Post-harvest processing cost.

The cost of production and profit from each type were analyzed by using statistics 8 software.









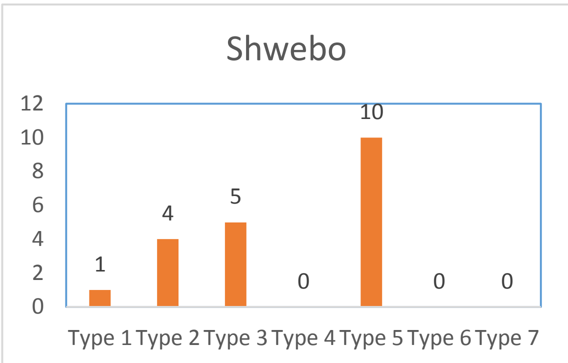


Figure 31: Number and types of demonstration plots in respective Townships

Results and Discussion

Land Equivalent Ratio (LER) for different intercropping practices

Plant population is the number of plants per unit area and it is useful to know optimum or critical population densities to avoid population as limiting factor for crop yield. Very high population density particularly in branching crops has negative effect because of competition for sun light. According to Willey[10], intercropping gives a yield advantage when the total plant density is higher than that of either of the sole crops. Land equivalent ratio (LER) is the relative land area under sole crops that is required to produce the yield achieved in intercropping.[11] In terms of total population pressure, two broad classes of intercropping systems can be distinguished: one is substitutive or replacement and another is additive or superimposed intercropping system. Here, it was found that, according to LER analysis and population density, Type-1 and Type-2 are sole cropping systems, while Type-7 is substitutive intercropping system. The remaining Types-3-4-5-6 are additive or superimposed intercropping systems.

The average LER record in each type of demonstration plots varied from 1 to 1.57 (Fig. 32). Significantly, higher LER was recorded from Type-5, where two rows of pigeon pea were intercropped with 5 rows of groundnut, while 2 rows of green gram were added inside 2 rows of pigeon pea. The mean total value of land equivalent ratio of Type-3, Type-4 and Type-6 were more than 1.0 indicating that intercropping of groundnut with pigeon pea and green gram were advantageous over sole crops alone. However, the land equivalent ratio of Type-7 was 1.0, as one row of sorghum was substituted to the row of pigeon pea. Efficient use of land resource, where land shortage inclines the farmers to grow many crops on small pieces of land, is one of the rationales of intercropping in the traditional farming systems.

Land Equivalent Ratio (LER)

Land equivalent ratio (LER) is the most common index adopted in intercropping to measure the land productivity. It is often used as an indicator to determine the efficacy of intercropping.[12] The LER is a standardized index that is defined as the relative area required by sole crops to produce the same yield as intercrops.[13]

The LER is determined by following formula:

$$\text{LER} = \frac{\text{Yield of crop (A) in intercropping plot}}{\text{Yield of crop (B) in mono-cropping plot}} + \frac{\text{Yield of crop (B) in intercropping plot}}{\text{Yield of crop (B) in mono-cropping plot}}$$

Table 7: Land equivalent ratio of each type of demonstration plots

[10] Willey, R. W. (1979). Intercropping: its importance and research needs. Part I. Competition and yield advantages. Filled Crops, 1-10.

[11] N. Khatri, K.D. (2014). Productivity and economic assessment of maize and soybean intercropping under various tillage and residue levels in chitwan, Nepal. World Journal of Agricultural Research, 6-12.

[12]Brintha, I., and T.H. Seran. (2009). Effect of paired row planting of raddish (Raphanus sativusL.) intercropped with vegetable amaranths (Amaranths tricolor L.) on yield components in sandy regosol. J. Agric. Sci. 4:19-28.

[13] Mead, R., and R.W. Willey. (1980). The concept of a „"Land Equivalent Ratio"" and advantages in yields from intercropping. Expl. Agric. 16: 217-228.

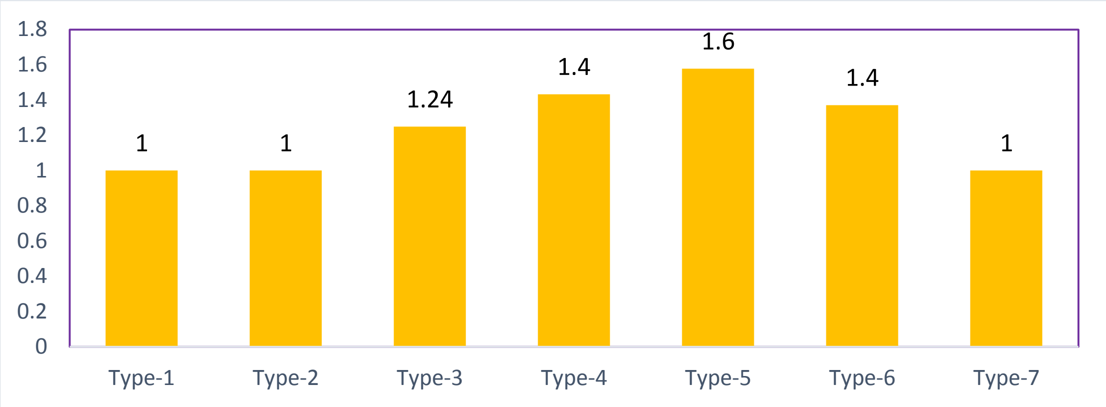


Figure 32: Land Equivalent Ratio (LER) of each type of demonstration plot

Comparison of net profits from different cropping practices

Economic evaluation based on net profit income is a crucial part of this report. It is important to remember how different townships have different geographical and environmental conditions. Therefore, the comparison of net profits from different cropping practices was performed within the Township. The plots of different types of practices were randomly selected. The yield and net income from each type of different intercropping practices were compared.

In Nyaung U Township, Type-4 showed the highest net profit, followed by Type-3 and Type-5. Type-6 gave the lowest net profit.

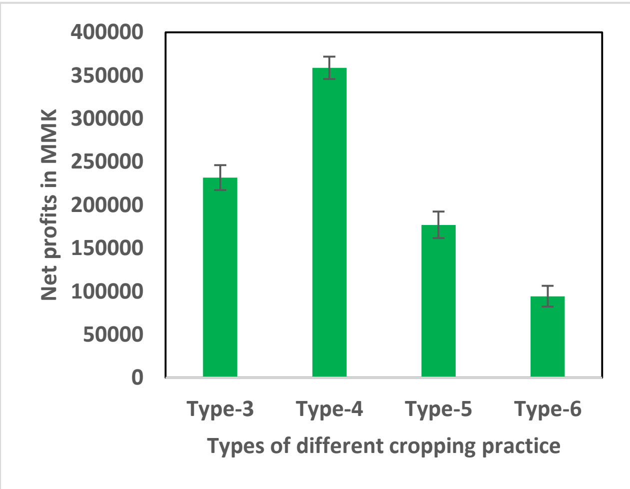


Figure 33: Comparison of Net Profits from different cropping practices in Nyaung U Township

For Chauk Township, Type-5 was the most successful practice giving the highest net profit. Type-3 and Type-6 showed moderately benefit. Type-4 was the least successful practice as giving low profit.

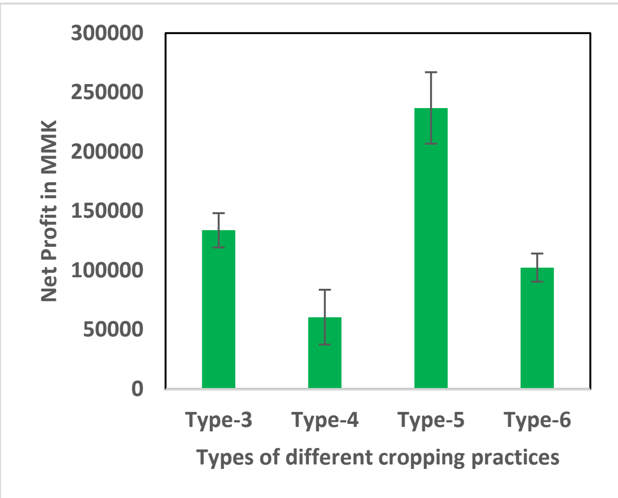


Figure 34: Comparison of Net Profits from different cropping practices in Chauk Township

In Myingyan Township, all types of demonstration practice showed high economic return and Type-5 and Type 4 gave the highest net profit. Type-3 and Type-1 also gave moderately benefits. Type-6 showed the lowest benefit.

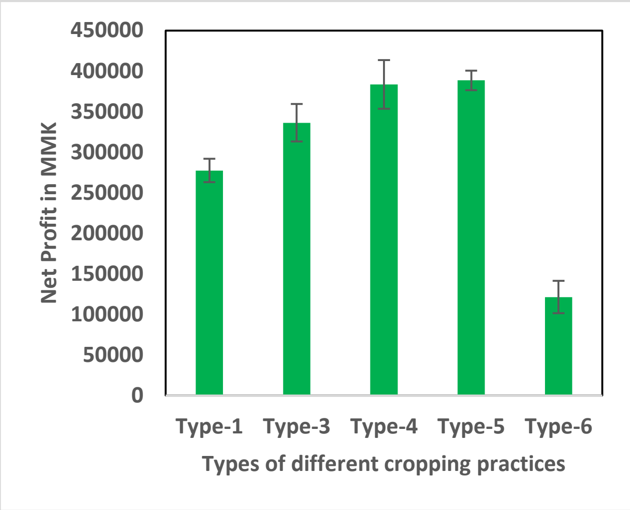


Figure 35: Comparison of Net Profits from different cropping practices in Myingyan Township

In Monywa Township, Type-5 showed the highest benefit followed by Type-7.

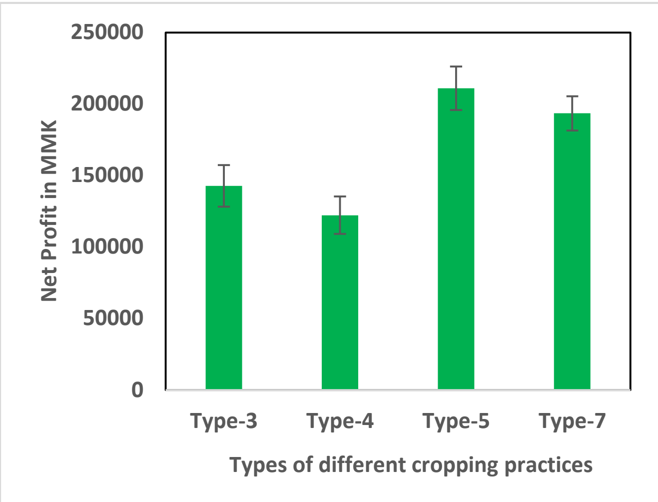


Figure 36: Comparison of Net Profits from different cropping practices in Monywa Township

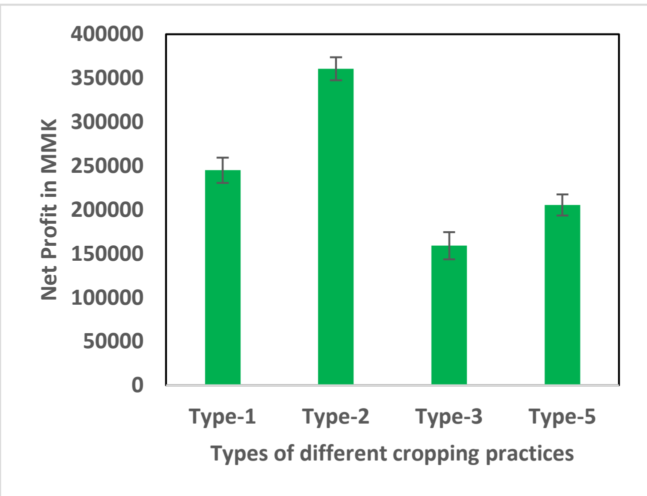


Figure 37: Comparison of Net Profits from different cropping practices in Shwebo Township

In Shwebo, gypsum application in rice cultivation practice was the most successful practice showing the highest benefit for the famers. Rice cultivation with less water requirement variety showed the second successful practice followed by Type-5 and Type-3.

Discussion

Groundnut, green gram and pigeon pea intercropping systems in rainy season could be grown successfully and found superior economic return in Nyaung U Township. Significant reduction in cost of cultivation under intercropping sorghum with pigeon pea worked out in Monywa Township, as this practice is not labor intensive. Type-6 (sesame based intercropping practice) was unsuccessful. According to the discussion with Technical staffs from DOA and DAR, the practice faced some challenges because of sesame growing time. Type-6 could give some reasonable benefit to the farmers, if time of sowing could be shifted to monsoon season (July- August). As the soil condition in Myingyan Township is better than in Nyaung U and Chauk Townships, all types implemented in 2017 gave reasonably high economic return to the beneficiaries. Since Shwebo is a rice growing area, rice cultivation with Gypsum application practice gave the highest economic return. It can be assumed that farmer's adaptation to the cropping practice is the most important factor to get the higher economic return. At the same time, drought resilient rice variety did not have a lot of market opportunities, even though some local traditional rice-based snack maker appreciated the new rice variety of *Ye Ah Ne Lo 4*, which was more stick than local variety.

Success Story

U Myint Soe and his wife Daw Than Tin are living in Kanma village, in Nyaung U Township and they are very active participants. They faced difficulties, affecting their mono-cropping groundnut, which made them extremely vulnerable to climate-induced shocks, such as erratic rainfall during the groundnut harvesting period in October 2016. In 2017 they have been selected by the project to apply intercropping practices.

Up to the present, they collected 8 baskets of green gram seeds, earning 240,000 kyats, which is the same income previously earned from growing groundnut alone in the monsoon season. Additionally, they could harvest 18 baskets of groundnut; earning 234,000 kyats from advance mix cropping system of project provide demonstration farms. "Green gram, Yezin-14 is short duration variety and we can get income early when compare to other crops groundnut and pigeon pea" said U Myint Soe. "We never have idea on short duration such as this variety before. I thought the quality of soil in my field is not very good for these crops, however, now I understood it is very suitable with better performance in the field. He also said that: "10 farmers in my village and 10 farmers from other villages visited my demonstration plot. They are interested to grow these short duration varieties and mix cropping technology, to overcome climate and market challenges." He is telling with smiling face "I now clearly understand that intercropping and mix cropping has potential to be promoted as adaptation practice across the Dry Zone".

Recommendation and Scaling Up

Land Equivalent Ratio (LER) of intercropping/mixed cropping is higher than mono-cropping/pure stand which means that, intercropping could give more productivity and more resilience on climate variability than mono or pure crop cultivation. Additionally, intercropping can support resilience to economic variability, due to sudden changes of agriculture product price in dry zone of Myanmar. Cesvi, DoA, DAR and UNDP organized a workshop with the aim of reviewing the lessons learnt from tested intercropping practices and to plan for upgrading on high performance existing intercropping methods and new intercropping system, for example with cotton instead of pigeon pea for innovation in 2018.

Figure 38: Drought Resilient Rice variety (Ye Ah Ne Lo 4) demonstration plot in Ohn Pauk village of Shwebo Township

Figure 39: Groundnut and pigeon pea cropping pattern in Sar Taung (East) village of Chauk Township

Figure 40: Alternative inter-cropping demo plot of Groundnut + Pigeon pea + Green Gram in Kanma village of Nyaung U Township

Figure 41: Alternative inter-cropping demo plot of Groundnut + Pigeon pea + Green Gram in Kyauk Kan village of Myingyan Township

Figure 42 Advance mix cropping demo plot of Pigeon pea, Groundnut and Green Gram plot in Au Yin West village of Chauk Township

Figure 43: Sesame based cropping demonstration (Sesame + Pigeon pea) plot of Sar Taung (East) village in Chauk Township

Figure 44: Pigeon pea based demonstration plot (Pigeon pea + Sorghum) in Nyaung Pin Ywar Thit village in Monywa Township

Project Township: Myingyan
Village: Kyauk Kan
Name of farmer: Daw Win Swe
Project support packages:
2-day training:Completed on 8-9 May 2017
Activity:
Participatory Demonstration Plot (Type IV)
- Groundnut (*Sinpadathar* 11variety) – 3 bsk.
- Green gram (Yezin 14 variety) - 0.25 bsk.
- Pigeon pea (*Monywa Shwedingar* variety) – 0.13 bsk.

Crop arrangement: Pigeon pea (1 row) + Green gram (5 rows) + Pigeon pea (1 row) + Groundnut (5 rows) + Pigeon pea (1 row) …
Crop area (acre): 1.00 acre
Date of sowing: 27 May 2017

Crop arrangement of Demo Type 4

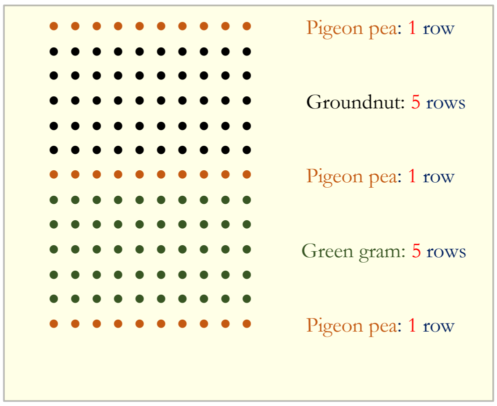


Figure 45: Example of applied intercropping

Plan for 2018

According to the agreement between UNDP and Cesvi and the budget plan, 145 plots have been designed for participatory demonstration plots in 2018. The number and types of cropping practices to be implemented in each township are summarized as follows:

Type	Crop combination	Nyaung U	Myingyan	Chauk	Monywa	Shwebo
1	Drought resistance rice variety		4			5
2	Gypsum application in rice production		5			10
3	Groundnut based intercropping practice (Groundnut 10 rows + pigeon pea 1 row) Relay groundnut pre-monsoon with groundnut monsoon	10	5	7	10	
4	3 crops intercropping (groundnut 6 rows + pigeon pea 1 row + green gram 6 rows)	10	5	6		
5	Relay cropping practice (Green gram 10 rows + pigeon pea 1 row) After harvesting green gram, sesame 8 rows will be grown	10	5		10	
6	Groundnut based intercropping Groundnut 10 rows + sorghum 2 rows		5			10
7	Groundnut based intercropping Groundnut 6 rows + cotton 2 rows		5	5		
8	Cotton based intercropping Cotton 4 rows + pigeon pea 2 rows				5	
9	Local long duration groundnut intercropping (groundnut 10 rows + green gram 1 row + pigeon pea 1 row + green gram 1 row)	2		8		
10	Participatory groundnut varietal selection	1		1		
11	Participatory cotton varietal selection		1			
	Total	**33**	**35**	**27**	**25**	**25**