Feed the Future Innovation Lab for Food Security Policy

Research Paper 131 May 2019

Burma Food Security Policy Project (FSPP)

AGRICULTURAL RESEARCH CAPACITY AND EXTENSION LINKAGES IN MYANMAR: ASSESSMENT AND RECOMMENDATIONS

By

Duncan Boughton and Su Su Win

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Authors' Acknowledgment:

This report was prepared by Dr. Duncan Boughton and Dr. Su Su Win on behalf of the Department of Agricultural Research Task Force (established by former Permanent Secretary of MOALI, Dr Tin Htut). The authors express their sincere appreciation to U Naing Kyi Win, Director General of the Department of Agricultural Research, for his leadership and commitment to ensuring that Department of Agricultural Research (DAR) researchers are able to make the most effective contribution possible to the welfare of Myanmar farmers, and to all Task Force members for their active and constructive participation. The author also express their thanks to Kristin Davis and Isabel Lambrecht (both of IFPRI), Ben Belton (MSU) and Matt Curtis (USAID) for valuable observations.

Over the course of a 35-year career the lead author has rarely encountered the level of expertise and dedication shown by DAR staff at all levels. DAR has already achieved much progress with limited funding, personnel and infrastructure, and with appropriate support they will make even more significant contributions to MOALI's vision for food and nutrition security, farmer welfare and economic growth.

Financial support for this review was provided by USAID Burma through the Food Security Policy Project and by the Livelihood and Food Security (LIFT) Fund. The findings and recommendations are entirely those of the author.

This study is made possible by the generous support of the American people through the United States Agency for International Development (USAID) under the Feed the Future initiative. The contents are the responsibility of the study authors and do not necessarily reflect the views of USAID or the United States Government

Published by the Department of Agricultural, Food, and Resource Economics, Michigan State University, Justin S. Morrill Hall of Agriculture, 446 West Circle Dr., Room 202, East Lansing,

EXECUTIVE SUMMARY

Agriculture, forestry and fishing accounted for 26.2% of Myanmar's $69.3 billion Gross Domestic Product (GDP) in 2017 (World Bank, 2018). An improvement of just one percentage point in Myanmar's agriculture sector growth rate would add more than $180 million per year to the economy, amounting to almost an additional $2 billion over a decade. Furthermore, a high proportion of these gains will accrue to low income rural households and urban consumers, with important multiplier effects for the rural economy. Yet, **Myanmar has one of the smallest, most underfunded, agricultural research systems in Southeast Asia.** According to the World Bank's Agricultural Public Expenditure Review, Myanmar invested the equivalent of only 0.04 % of agricultural GDP in agricultural research. Other Asian countries invest 0.60 % of their agricultural GDP in research, more than ten times as much as Myanmar (World Bank 2017). Countries with advanced research systems spend 40 times as much as Myanmar when measured as a share of agriculture's contribution to their economies. An example of the consequences of underinvestment in agricultural research over a prolonged period is that, even for rice, some of Myanmar's most widely grown varieties are over 40 years old.

The justification for high rates of investment in agricultural research is the strong historical evidence of its contribution to high rates of agricultural growth, poverty reduction and improved nutrition outcomes. An extensive review of returns to research and extension found average annual rates of return in excess of 60% (Alston et al., 2000). The returns to investment in Myanmar could be even higher than average given the country's agricultural potential. Failure to address the current gaps in research capacity, organization and funding will have negative consequences. Myanmar farmers and agribusinesses will face lower incomes and higher climate-related losses, Myanmar consumers will pay more for their food, while a higher share will be imported from the international market. The high cost of the nutrient-rich components of a healthy diet (e.g., meat, fish, eggs, fruits and vegetables) relative to consumer purchasing power is already a major constraint to improved nutrition outcomes in Myanmar, especially in hilly regions and urban areas (Mather and Mahrt, 2019).

Myanmar has critical **gaps in research capacity.** Myanmar has well-trained and highly dedicated agricultural scientists, but they are very few in number. Despite enormous growth potential in aquaculture and livestock production, for example, Myanmar has very limited research capacity for these sectors beyond laboratory research conducted by universities or government departments. Even the main research organization for crop production, Department of Agricultural Research (DAR), has only 100 graduate staff (25 PhD level and 75 MSc level). While crop variety improvement is the largest component of DAR activities, there are very few crop breeders on staff. Modern breeding approaches require strong support from biotechnology, and Myanmar's biotechnology laboratories have very limited staff and equipment. Besides crop breeding and biotechnology, research capacity is lacking in aquaculture and fisheries, livestock production, forage production, cropping systems agronomy, soil and water management, pest and disease management, agricultural mechanization and socio-economic analysis.

Myanmar's agricultural research capacity is highly fragmented. There are more personnel with PhD training in the Department of Agriculture (DOA) than DAR. For example, the DOA's Plant Biotechnology Centre outside Yangon has 12 PhDs compared with only 2 PhDs in DAR's

Biotechnology Research section in Yezin. Consequently, the DAR staff responsible for crop improvement programs do not have the necessary biotechnology capacity to support efficient breeding programs. Many PhD level staff in DOA are not undertaking research. Instead they are assigned to management tasks or as counterparts to international projects because of the English language skills acquired through advanced degree training.

The current organization of DAR's research programs **does not facilitate a problem solving approach**. Research programs are developed at the administrative sub-unit level on the basis of individual crops or disciplines, making it difficult to design and implement multi-disciplinary approaches to problems farmers encounter in the country's diverse production systems. DAR's 25 research stations have specific crop mandates that are not always well matched to the predominant cropping systems in their location. A large part of the land area and budget of DAR research stations is devoted to seed multiplication rather than to research, often multiplying seed of outdated varieties rather than new ones. **Linkages between research and extension at the local level are very weak,** limited to extension participation at research station field days. Most research stations lack graduate leadership as 75% of DAR's MSc level staff and 90% of PhD level staff are located at the Head Quarter (HQ) station in Yezin.

The **lack of incentives for researchers discourages lifetime productivity**. Myanmar's public sector salaries are extremely low. An individual with a Bachelor's degree in agriculture can earn more in an entry-level position with a Non-Governmental Organization (NGO)/International Non-Governmental Organization (INGO) or donor project than as a senior researcher with a PhD in government service. More than 85% of Myanmar's scientists are women because men do not think they can support a family if they stay in research. Promotion to higher grades is a very slow process, typically through transfer to a position with administrative responsibilities. There is no dedicated research career ladder for researchers to achieve the equivalent grade of a senior administrator. Retention of young scientists can be difficult if they return from advanced training overseas with skills they cannot apply on their return due to lack of facilities, budget and continued mentoring.

The **lack of an overall strategy for the development of Myanmar's agricultural research and extension system** results in the inefficient use of international partnerships. Large, well-meaning, bilateral initiatives focused on a specific crop or research area, often accompanied by significant investment in new buildings, run the risk of undermining existing programs if scarce qualified personnel have to be transferred to implement the new high-profile initiatives. One solution to this is to require international projects to include funding for Myanmar researchers to undergo advanced degree training, and to provide temporary resident qualified international staff for the period of training as well as to mentor newly returned graduates.

The new Agricultural Development Strategy (ADS) and investment plan for MOALI, launched on June 7, 2018, provides **a timely opportunity to overcome the constraints and system weaknesses** identified above. As part of the Productivity Pillar, the ADS proposes a unified National Agricultural Research and Extension System (NARES). The NARES should include research and extension activities implemented by the private sector, NGOs/INGOs, universities and CGIAR centers, as well as MOALI. The Regional Research Centre (RRC) concept, currently being piloted in Sagaing Region, provides a decentralized model for MOALI research and extension staff to work together with farmers to identify problems and test solutions. The RRC model should

be expanded to include participation by private sector stakeholders (e.g., traders, processors, input suppliers) and NGOs.

The **current underinvestment and lack of research capacity is a significant threat to Myanmar's agricultural productivity and the future wellbeing of Myanmar citizens, especially in rural areas**. The following actions can be taken immediately by MOALI to improve public sector research effectiveness in ways that are consistent with the development of the NARES:

1) Establish an agricultural research and extension strategy leadership team comprised of Director Generals of all MOALI units with research mandates and activities. Initial tasks will include:
    a. Prepare an inventory of human resources with advanced research degree training across MOALI and their current functions;
    b. Re-assign staff with recently completed advanced research degrees who are currently performing administrative or project management functions to research activities;
    c. Develop a consolidated advanced research degree training program and budget;
    d. Develop a performance-based research career progression with financial and non-financial incentives to retain trained capacity in research functions;
    e. Ensure that the Technical Seed Committee and National Seed Committee meet regularly to evaluate submissions for the release of improved varieties;
    f. Explore potential for expanded licensing of publicly owned hybrids and Open Pollinated Variety (OPV)/Self-Pollinated Varieties (SPV) to the private seed sector to accelerate commercialization and access by farmers.
    g. Undertake a preliminary analysis of the potential increase in value of agricultural output from research on majors crops, livestock, aquaculture and farming systems to guide research investment allocation;
    h. Publish a single MOALI five year agricultural research and extension plan and budget with specific targets for improved technology release/dissemination and adoption;
    i. Publish an annual report on agricultural science accomplishments and impact at farm level.

2) Organize research planning, budgeting and Monitoring and Evaluation (M&E) according to three main programs: 1) Genetic Improvement; 2) Production Systems Management and 3) Farming Systems Development. The purpose of the Genetic Improvement program is to identify or develop improved varieties or breeds adapted to Myanmar's markets and agro-ecologies. The purpose of the Production Systems Management Program is to identify or develop more efficient production and post-harvest management practices for integrated cropping systems, livestock and aquaculture. The purpose of the Farming Systems program is to engage farmers and agribusinesses working on all major farming systems in the country in the identification of problems, testing of improved technologies together with farmers and agribusinesses, and develop plans for scale-up with extension services. Each of the three main programs would have sub-programs that collaborate on shared objectives with efficient use of shared resources (e.g., biotechnology);

3) Undertake expert technical reviews for each major research program and sub-program to identify priority genetic or production management improvements, as well as potential pest and disease threats to be countered, for each of Myanmar's major production systems over the next five years;

4) Accelerate progress in crop breeding by forming a critical mass of researchers and facilities in breeding and biotechnology working together across Departments on priority crops or species in combination with international advanced research institutes (one MOALI department should be given lead responsibility for managing joint programs for each crop or species);

5) Finalize a biotechnology policy, law and safety framework to maximize the potential for the safe acquisition and deployment of biotechnology innovations that can benefit farmers and consumers;

6) Accelerate and expand geographical coverage for the testing and dissemination of improved varieties/species and/or management practices at farm level through collaboration between research and extension resources of MOALI at regional level (Regional Research Centre model) and focusing seed multiplication effort on early generation multiplication of pre-lease materials;

7) Strengthen Regional Research Centre research and extension activities through multi-disciplinary teams, including socio-economists to help monitor the impact of adoption of improved genetic materials and techniques;

8) Engage local private sector operators, such as seed companies, agricultural traders and processors, in the identification and promotion of promising genetic materials and techniques;

9) Accelerate variety and product registration and release procedures for public and private sector technology providers; and

10) Privatize and ensure independent quality control of non-research functions such as tissue culture, non-early generation seed multiplication, breeding stock production, or production of soil health materials.

TABLE OF CONTENT

LIST OF FIGURES

LIST OF TABLES

ACRONYMS

ACIAR	Australian Centre for International Agricultural Research
ADS	Agricultural Development Strategy
AFRE	Department of Agricultural, Food, and Resource Economics
AgPER	Agricultural Sector Public Expenditure Review
AIS	Agricultural Innovation System
AVRDC	World Vegetable Center
BLB	Bacterial Leaf Blight
CGIAR	formerly the Consultative Group for International Agricultural Research
CIMMYT	International Maize and Wheat Improvement Center
DAR	Department of Agricultural Research
DOA	Department of Agriculture
DOP	Department of Planning
EGS	Early Generation Seed
FSP	Feed the Future Innovation Lab for Food Security Policy
FTE	Full Time Equivalent
GDP	Gross Domestic Product
HQ	Head Quarter
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IFPRI	International Food Policy Research Institute
INGO	International Non-Governmental Organization
IRRI	International Rice Research Institute
LIFT	Livelihood and Food Security
MAS	Marker Assisted Selection
MLFRD	Ministry of Livestock, Fisheries and Rural Development
MOALI	Ministry of Agriculture, Livestock and Irrigation
MSU	Michigan State University
M&E	Monitoring and Evaluation
NARC	National Agricultural Research Council
NARES	National Agricultural Research and Extension System
NGO	Non-Governmental Organization
OPV	Open Pollinated Variety
PHI	Post-Harvest Institute
RRC	Regional Research Centre
SPV	Self-Pollinated Variety
SWOT	Participatory Strengths, Weaknesses, Opportunities and Threats
USAID	United States Agency for International Development
YAU	Yezin Agricultural University

INTRODUCTION

Agriculture is a key sector for Myanmar's economy. In addition to ensuring national food and nutrition security, the sector has a unique advantage for achieving broad-based poverty reduction given that 87% of Myanmar's poor live in rural areas (MOPF, 2017). Growth in the productivity and incomes of Myanmar's farms can help drive growth in the rural economy through farm employment and incomes, as well through service industries such as farm mechanization rental services, transport, value-added processing and retailing. Domestic and regional food markets are growing rapidly, especially for higher value produce like fruits, vegetables, fish, meat, eggs and dairy products. Yet the actual rate of agricultural growth in Myanmar has been less than half that of the overall growth rate of the economy averaged over the past five years (World Bank, 2017). Increased rural incomes and year-round availability of diverse and affordable nutrient sources are essential drivers of improved nutrition outcomes (Mather and Mahrt, 2019).

An effective NARES[1] is essential to realize the full potential of Myanmar's agricultural resources and to contribute to the government goals of economic development, food and nutrition security, and poverty eradication. The benefits of an effective NARES include:

1) increased productivity, profitability and reduced risk for Myanmar farmers;

2) increased quantity, quality, diversity and affordability of food for Myanmar consumers;

3) increased value of agricultural exports;

4) reduced losses in the face of climate variability;

5) higher levels of employment in the off-farm parts of the food system adding value through trading, processing, and distribution;

6) reduced income gap between rural and urban households, and therefore a more manageable rate of outmigration from rural areas; and

7) preservation of the natural resource base.

Furthermore, through the identification, dissemination and adoption of improved varieties and breeds of livestock and fish, together with improved production and post-harvest practices, an effective NARES will increase returns to private investments in the agricultural sector (e.g., irrigation, mechanization, and value-added processing).

The first Agricultural Sector Public Expenditure Review (AgPER) states that "Public investments in agricultural research and complementary programs extending research results to farmers (extension, soil nutrient management, plant protection, etc.) are found to generate the highest rates

[1] The World Bank uses the concept of an Agricultural Innovation System (AIS) rather than NARES to encourage a more inclusive concept in terms of participants and stakeholders, stages in the value chain, and types of technology, than that prevailing in the pre-ICT green revolution era. This discussion paper users the same terminology as the Agricultural Development Strategy while embracing the AIS concept.

of return around the world. No country could generate long-term agricultural growth without such investments." (World Bank, 2017, page xv).

ADS of MOALI recognizes the importance of agricultural research and that agricultural research and extension are extremely underfunded (MOALI 2018). The ADS acknowledges the gap in research for livestock and aquaculture. It also acknowledges that crop research is undertaken by different departments with no overall national research plan, and linkages between research and extension are underdeveloped. The ADS recommends that MOALI "reorganize its research governance under a national structure, remove research duplication where it exits, create new research capacity where necessary, and build research center linkages to ensure a farming systems approach to research planning" (ibid. p19). The ADS specifies an "Improved research system for crop, livestock and fisheries and improved research-extension coordination systems with participation of farmers and private sector" as the first outcome under the Productivity Pillar (ibid p52). Following the launch of the ADS on June 7, MOALI plans to work on the first two outputs related to this outcome as early actions: a National Agricultural Research Council (NARC) will be established to provide overall guidance to agricultural research, and an agricultural research master plan to establish research priorities and programs in line with broader ADS outcomes. An action research fund will also be established and allocated by the NARC.

In support of the ADS, DAR undertook a preliminary diagnostic of its strengths and weaknesses in collaboration with the Agricultural Policy Unit (APU) of the Department of Planning (DOP). This report presents the key findings and recommendations of the diagnostic exercise for the research component, as well as research-extension linkages, of the proposed NARE. The recommendations identify immediate steps that can be taken by DAR to improve its effectiveness, develop its contribution to the agricultural research master plan, and address more complex programmatic and capacity weaknesses. The report focuses primarily on DAR because research on aquaculture and livestock production in Myanmar is currently very limited in scope[2].

METHOD

In anticipation of the new ADS, DAR undertook a preliminary diagnostic of its strengths and weaknesses. The Director General of DAR formed a task force comprised of senior representatives of all major programs, as well as young scientists (see Annex 1 for a list of task force participants). The diagnostic was undertaken in collaboration with the Agricultural Policy Unit of the Department of Planning.

The study was undertaken using the following steps:

1) Participatory Strengths, Weaknesses, Opportunities and Threats (SWOT) analysis at institution and research section levels.

2) Field visits to 8 DAR research stations.

3) Key informant interviews with HQ program staff.

4) Presentation and discussion of findings at national research and extension meetings.

[2] The Research and Development Division of the Department of Fisheries, for example, is mainly focused on the provision of training services through three regional centers: the Institute of Fisheries Technology, Yangon; the Upper Myanmar Fisheries Training Center, Sagaing; and the Ayeyarwady Fisheries Training Center, Pyapon.

5) Development and launch of an RRC pilot program to strengthen linkages between research, extension and farmers in Sagaing Region.

As an initial diagnostic this study has several limitations. It identifies constraints based on participatory feedback but cannot diagnose problems in sufficient detail to make specific recommendations for all areas. For example, researchers frequently note that cumbersome financial procedures make it very difficult to expend allocated budgets, but this diagnostic does not recommend specific improvements to financial administration. Similarly the study has not looked in any detail at library resources, IT system, or communications. Such topics are very important for any research organization, and will need further specialized analysis to evaluate and make recommendations for improvement. Furthermore, specific studies should be undertaken for livestock and aquaculture research.

CURRENT ORGANIZATIONAL STRUCTURE, CAPACITY AND RESEARCH ACTIVITIES OF DAR

a) Introduction to DAR

DAR is a Department of the Ministry of Agriculture, Livestock and Irrigation (MOALI), a Ministry created in 2016 by the merger of three previous Ministries: the Ministry of Agriculture and Irrigation (MOAI), the Ministry of Livestock, Fisheries and Rural Development (MLFRD), and the Ministry of Cooperatives. DAR was established on the outskirts of Yangon in 1954 and moved to its current location in Yezin in 1971. It became a separate Department in 2004.

The vision of MOALI is "An inclusive, competitive, food and nutrition secure and sustainable agricultural system contributing to the socioeconomic wellbeing of farmers and rural people and further development of the national economy." The current vision of DAR is "Food security and nutrition with the impact of innovative advanced crop variety and production technology research". The vision of DAR is close to, but not completely aligned with, the new vision of MOALI. It focuses on food security, but does not explicitly address farmer incomes, sustainability or broader contributions to economic development from post-farm value added. In fact, a number of DAR research activities are already addressing some of these broader concerns even though not explicitly stated in the current DAR vision.

The mission of DAR is "To systematically conduct research and development on rice, maize and other cereal crops, oilseed crops and food legumes, industrial crops and horticultural crops, soil and water utilization, agricultural engineering, cropping systems and agricultural economics, biotechnology, seed bank and germplasm conservation and plant protection." This mission statement has the advantage of encompassing most of the activities of DAR, but misses the target audience for its work (farmers, consumers and agribusiness). It also misses essential linkages necessary to its success, internal and external, such as extension services and the private sector.
A modified mission statement aligned with the ADS could read as follows: "The mission of DAR is to harness the potential contribution of global crop and soil sciences, in collaboration with farmers, extension services, the private sector and international advanced research institutes, to achieve the vision of MOALI." Although DAR is currently focused on plant and soil sciences, livestock and aquaculture research must also be strengthened and integrated into a unified NARES

to realize the full potential contribution of agricultural science to Myanmar's faming and food system development.

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b) Organization and Resources of DAR

This section provides a description and analytical review of DAR's organizational structure, human resources, and budget allocation.

i. Organizational structure

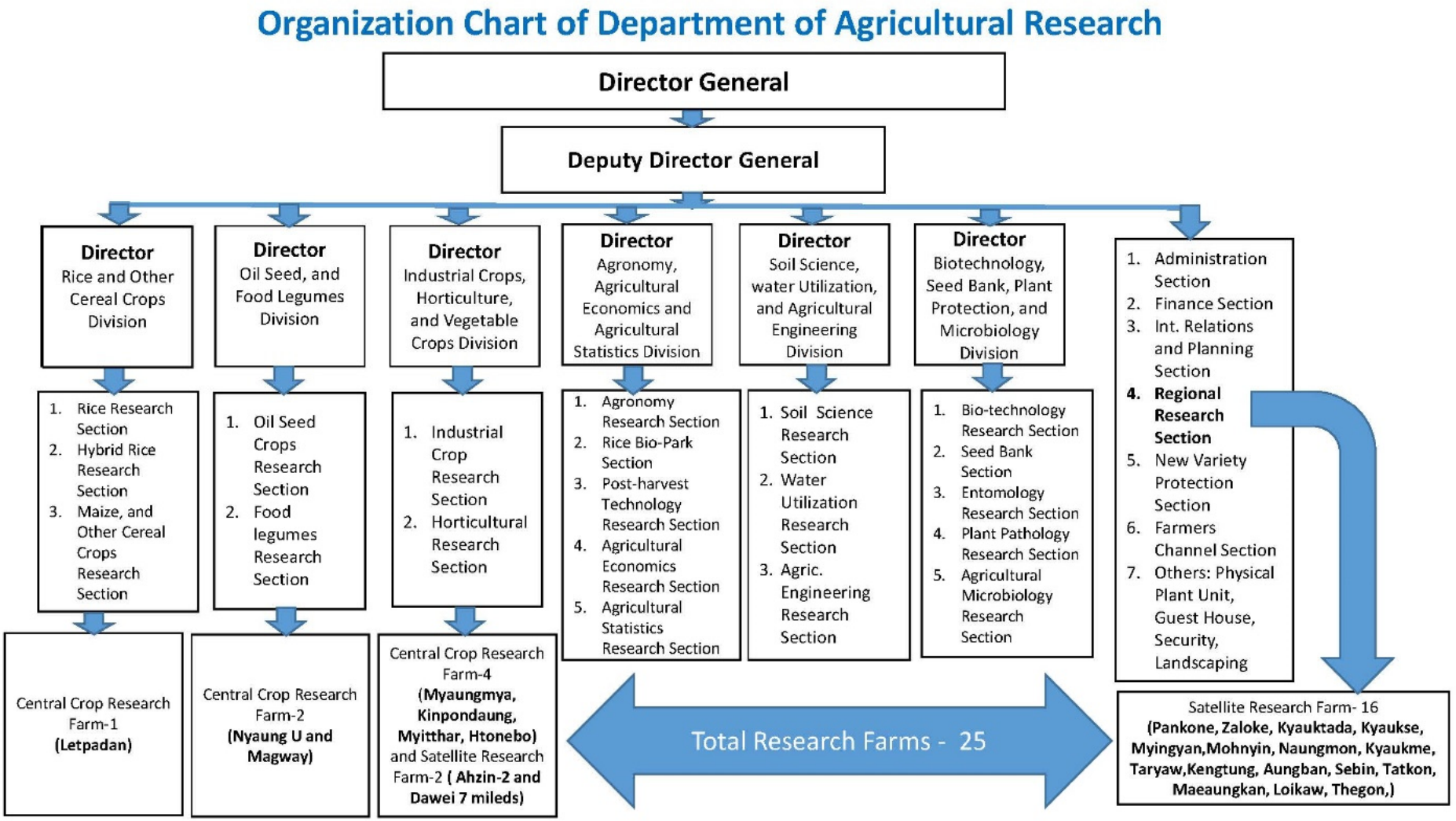
DAR is organized into 6 technical divisions and one division for administration and finance, all located at the headquarters location in Yezin (Figure 1). Each technical division is sub-divided into research sections specializing in specific crops or disciplines. The technical divisions (with number of subdivisions in parentheses) include:

- Rice and Other Cereal Crops Division (3)
  - One central crop research farm
- Oil Seed and Food Legumes Division (2)
  - Two central crop research farms
- Industrial Crops, Horticulture and Vegetable Crops Division (2)
  - Four central crop research and two satellite research farms
- Agronomy, Agricultural Economics and Agricultural Statistics Division (5)
- Soil Science, Water Utilization and Agricultural Engineering Division (3)
- Biotechnology, Seed Bank, Plant Protection and Microbiology Division (5)

There are a total of 20 technical research sections under the six divisions. The administration and finance division also houses the Plant Variety Protection section, the Farmers Channel (TV) section and 16 satellite research farms (in addition to those listed above under the responsibility of technical divisions). Each research section within DAR is responsible for developing its own research workplan and budget, which is reviewed at the national agricultural research extension planning meeting held annually at headquarters in early May.

The fragmented organizational structure makes it difficult to design integrated programs that respond effectively to farmer problems of a cropping systems or multi-disciplinary character. It also makes it difficult to manage shared resources, such as biotechnology capacity. Given the very small size of DAR a structure of this complexity is unnecessary. An alternative approach to research program planning, which could be adopted even with the existing structure, is explained in section "Critical reforms and investments".

Figure 1: Organizational Structure of DAR[3]



Source: DAR

ii. Human Resources

DAR currently has 144 research staff at the Assistant Research Officer level or higher. Of this total, approximately 100 have graduate degrees, 25 at the PhD level and 75 at the MS level. The absolute number of research staff in DAR is very small, even before adjusting for non-research related duties such as management. Other countries in the region had the following Full-Time Equivalent (FTE) research staff in 2010: Laos 227; Cambodia 284; Malaysia 1,614; Bangladesh 2,121; and Vietnam 3,744[4].

Nearly all DAR's PhD level researchers are based at the HQ location in Yezin, as are the majority of MS level staff. The centralization of research staff in Yezin inevitably results in a high degree of centralization in research planning.

With such a small research staff DAR inevitably faces critical human resource deficits in almost every discipline when compared to the scale of the crop research needs of the country. Given the challenging climate, with high temperatures and high rainfall variability/intensity, a rapid scale up of scientific capacity is urgently needed. DAR's training plan calls for an additional 55 PhD/Post-doctoral recruits and 106 MS level recruits (see Table 1).

Analysis of the plan by discipline indicates that 60% of PhD/Post-doctoral level training and 50% of MS level training is in crop genetic improvement. Approximately one-third of proposed PhD/Post-doctoral level training, and one fifth of MS level training, is in the area of cropping systems management (e.g., agronomy, soil science, water utilization, pathology, entomology). One fifth of all proposed MS level training in is in the Agricultural Statistics and Economics research sections, which could be helpful for decentralization and on-farm research if there were also PhD level staff to provide leadership. Food Science and Nutrition is also targeted for significant scale up, with an additional 8 PhD and 8 MS level staff, reflecting investment in a new post-harvest research facility funded by South Korea.

The proposed training plan will allow for a doubling of the number of research staff over the next five years, after allowing for retirements and assuming the training plan is fully funded. This will greatly increase the potential for research output, but still leave Myanmar among the countries with the smallest crop research capacity in the region. To the extent that graduate training can include joint research activities between the host university and/or research institute it will help students stay connected to their DAR units and allow for continuing collaboration on their return. This is not always the case for current DAR staff on training. For example, two PhD candidates from the rice research section are not able to integrate their studies with their home research section, in one case because there is no agreement with the host country to allow the exchange of plant materials, and in another case because the location is in a different rice growing environment from Myanmar's predominant rice growing ecologies.

[3]Based on a presentation by U Naing Kyi Win, Director General, May 2nd, 2018. Includes research staff at the following ranks (numbers): Assistant Research Officer (85), Research Officer/Assistant Director (35), Chief Researcher/Deputy Director (18), and Director (6). Director General and Deputy Director General are not included in the total of 144 research staff.

[4] Agricultural Science and Technology Indicators (ASTI) database. www.asti.cgiar.org . The concept of full-time equivalent (FTE) research staff adjusts the number of researchers employed for the time they spend on non-research tasks.

Table 1: DAR post-graduate training plan

Research Division or Section	PhD / Post-Doc	MS
Rice	7	22
Maize & Other Cereals	4	11
Oil Crops	3	3
Food Legumes	4	3
Industrial Crops	4	8
Horticulture	2	1
Agronomy	5	4
Biotech	4	4
Soil Science	2	9
Water Utilization	2	6
Entomology	0	0
Pathology	7	5
Seed Bank	3	5
Post-Harvest	2	4
Rice Biopark	6	4
Statistics	0	10
Agricultural Economics	0	10
TOTAL	55	109

Source: DAR internal documentation provided to Task Force

Expanding and retaining well-qualified research staff will be difficult without improvements in conditions of service. Myanmar's public sector salaries are extremely low. An individual with a Bachelor's degree in agriculture can earn more in an entry level position with an NGO/INGO or donor project than as a senior researcher with a PhD in government service. More than 85% of Myanmar's scientists are women because men do not think they can support a family if they stay in research. Promotion to higher grades is a very slow process, typically through transfer to a position with administrative responsibilities. There is no dedicated research career ladder for researchers to achieve the equivalent grade of a senior administrator. Retention of young scientists can be difficult if they return from advanced training overseas with skills they cannot apply on their return due to lack of facilities and budget.

DAR has actively sought to recognize its researchers through prizes for a wide variety of accomplishments. Prizes are given for individual and team contributions, presented by the Minister and Director General, and are clearly highly appreciated. One source of discouragement in the past, however, has been irregular meetings of the Technical Seed Committee and National Seed Committee. This has resulted in the delayed release of several promising varieties. Since the ability to contribute practically to the welfare of Myanmar farmers is a very important part of

scientists' motivation it is essential that everything possible to be done to realize the potential contribution of their work.

One potential source of new recruits for DAR are Yezin Agricultural University (YAU) senior undergraduate internships. Unfortunately, the interns allocated to DAR are not necessarily selected by YAU for their interest in research. This weakness can easily be corrected. Furthermore, undergraduate internships could be expanded to more than a single semester to allow experience to be gained over two years, at Yezin HQ as well as at a research centre or satellite farm undertaking on-farm trials.

iii. Budget

According to the first AgPER, conducted by the World Bank, Myanmar invested just 0.04 of one percent of agricultural GDP in agricultural research in 2016/2017 (World Bank, 2017). The average level of expenditure in Asia is fifteen times higher as a share of agricultural GDP. In 2016/2017 almost 70% of DAR's recurrent budget was required to cover the cost of DAR's 25 research farms and satellite stations. This left only 1.5 billion kyat ($1.1 million) for other recurrent expenditures. One consequence of the small national recurrent budget is to make DAR highly dependent on externally funded activities. Due to the limited human resources and budget, large international projects focused on a specific crop or theme can result in significant changes to the overall research portfolio. In the past, decisions about such investments have often made at a very high level without fully anticipating the potential effects, positive and negative, on DAR as a whole. The ratio of DAR's capital to current expenditure varies considerably from year to year, mainly due to fluctuation in the capital budget, but the ratio of current to capital budget averaged 60:40 over the past four years.

c) Research Activities of DAR

This section provides an overview of DAR research activities. It is not intended to be either an exhaustive review or a critique of the choice of activities or methods used. The purpose is to describe the main research activities undertaken, document the difficulties that researchers encounter, and identify opportunities to improve effectiveness.

DAR research activities are planned according to the organizational structure described in section "3.2 Organization and Resources of DAR" and included in a 5 year research plan for the period 2016/17 to 2020/21. An annual meeting is held with extension each year to present results and agree priority activities. These include planning Early Generation Seed (EGS) requirements for DOA seed farms. The meeting is attended by all DAR's satellite farms which undertake multi-location trials and seed multiplication for their "mandate crops" (see Annex 2 for a list of research and satellite farms and their associated crop mandates). The discussion below follows the organizational structure presented in Figure 1.

i. Rice and other Cereal Crops

The Rice and Other Cereal Crops division is divided into three research sections: rice research section, hybrid rice research section; and maize and other cereal crops research section.

The rice research section focuses on identifying improved germplasm for the different rice growing environments of Myanmar. Almost half of the rice area in Myanmar is classified as

rainfed lowland, while a further 20% is irrigated. The remainder is composed of high risk / high challenge environments such as drought prone (12%), flood prone (14%), salt affected (3%) and upland (3%). The section has breeding objectives for each environment including yield performance, duration, flood tolerance, eating quality, and pest and disease resistance. The rice research section works closely with the International Rice Research Institute (IRRI) through a standard approach of observational nurseries, replicated yield trials, and on-farm trials. The approach takes a minimum of six years before farmers can have any exposure to breeder selections. The collaboration with IRRI has resulted in several releases, including the Bacterial Leaf Blight (BLB) resistant variety Pyi Taw Yin in 2015. BLB is a serious monsoon rice disease and the use of a resistant variety avoids the need for expensive chemical treatments.

The rice research section of DAR is extremely understaffed with just one MS level researcher and 2 post-graduate diploma holders. This situation is partly due to the decision to establish a separate hybrid rice research section, even though the area where hybrid rice varieties can outperform conventional varieties is a very small proportion of the total rice area planted in Myanmar. Four staff are currently undergoing PhD level training, one each in Australia, China, India, and Korea.

In addition to more graduate-level researchers, the rice research section could greatly benefit from expanded Marker Assisted Selection (MAS). The lack of high capacity equipment, and lack of access to liquid nitrogen, limit in-country access to MAS, while the lack of a biotechnology law and associated biosafety framework is a major barrier to collaboration with international advanced research institutes that could overcome domestic limitations.

The maize and other cereal crops research section conducts research on maize, wheat, sorghum and millet. Maize is the most important crop with growing export demand from China as well as increasing domestic demand for animal feed, especially poultry. Maize is also one of the few major field crops where the private sector is active in the supply of improved varieties, especially hybrids, which are widely grown in Shan State and other hilly areas. The section focuses almost exclusively on the identification of higher yielding varieties with disease and drought tolerance and collaborates with the International Maize and Wheat Improvement Center (CIMMYT), the International Corn Foundation and the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) on germplasm acquisition. The section has one PhD and 2 MS level staff. Over the past five years three hybrid and one OPV maize varieties have been released, together with one variety of fresh (sweet) corn. Two new promising open-pollinated varieties of sweet corn, and two short-duration hybrid varieties for use in lowland areas in the post-monsoon season, are in the pipeline. Six wheat varieties have also been released since 2013. No information is available on the extent of adoption. No improved varieties of sorghum and millet varieties have been released in the past 30 years, although sorghum is an important source of feed for draught animals.

The section has sought to collaborate with the private sector input suppliers through the supply of seed of improved varieties and would like to see this collaboration expand to include licensing arrangements to enable faster commercialization.

ii. Oilseed and Food Legume Division

The Oilseed and Food Legume division includes two research sections: a food legumes research section and an oilseed research section. The food legume research section focuses on varietal improvement of green gram (mungbean), black gram, chickpea, pigeonpea and soybean. DAR has released 12 varieties of green gram, 4 varieties of black gram, 6 varieties of pigeonpea, 9

varieties of chickpea, 12 varieties of soybean and 2 varieties of cowpea. In recent years, the release of several improved varieties of chickpea, which has much stronger domestic demand than the other pulses, has been a notable success. As with other crops, however, accurate information on adoption rates is lacking, and no private sector companies are multiplying seed of these varieties.

Yellow mosaic virus, transmitted by the white fly vector, affects large areas of green gram and black gram. One resistant variety of each gram type has been released. For black gram the section hopes to successfully cross a yellow mosaic resistant variety (Yezin 7) with a variety that can be mechanically harvested (Yezin 6). The section works closely with ICRISAT and World Vegetable Center (AVRDC), and until recently had a collaborative project with Australian Centre for International Agricultural Research (ACIAR) on pulse development.

The oilseed research section aims to identify improved varieties of groundnut, sesame and sunflower. Breeding goals are shorter duration for adaptability to climate in the major agro-ecological zones where oilseeds are grown, together with high yield and oil content. While locally produced vegetable oils struggle to compete with imports of palm oil, groundnut and sesame oil is highly valued in the market where its authenticity is trusted by consumers. The oilseed research section has one PhD and 2 MS level researchers. Three groundnut varieties, 3 sesame varieties (2 black, 1 white) and one hybrid sunflower variety have been released. No accurate information is available on adoption rates. The section expects to release one or more drought resistant groundnut varieties, and a replacement for the aging Yezin 1 sunflower hybrid.

Groundnut is an especially difficult crop for variety diffusion because of its low yield to seed ratio. Where concerted efforts have been undertaken for seed multiplication and dissemination through NGOs, as in Malawi, adoption rates have been high. In Myanmar, the promotion of groundnut varieties has been largely neglected, which is unfortunate in view of the high nutritional value of groundnuts for humans, and the haulms provide a valuable source of animal feed.

iii. Industrial Crops, Horticulture and Vegetable Crops Division

The Industrial Crops, Horticulture and Vegetable Crops Division includes two research sections – industrial crops and horticulture. The industrial crops research section mandate includes sugarcane, cotton, jute, kenaf and cassava. In practice only sugarcane has an active research program while research on other crops continues at a minimal level due to lack of staff, finance and access to genetic resources. The sugarcane sector is dominated by five large-scale private companies but surprisingly they have shown little interest in DAR's research program. DAR has released one sugarcane variety in 2015 after a gap of 30 years, and planting material of the new variety has been shared with companies who are evaluating the material.

The horticultural crops research section undertakes varietal improvement for tomato, chilli and eggplant. The unit is also developing good agricultural practices (GAP) for cabbage and cauliflower production, and testing an onion seedling system for commercial onion growers. The unit is also working on rose breeding.

Improvement of the well-known Myanmar mango variety, Sein Ta Lone, is a window of opportunity. The variety is very popular in domestic and export markets, especially China, but its thin skin makes the current variety vulnerable to damage in transit. The development of early and late maturing varietals would extend the marketing season.

The development of early maturing, dwarf banana varieties is another window of opportunity. Traditional varieties require bamboo props to prevent lodging, which adds significant cost. Reducing the duration to a mature crop from the current 12-15 months to 10 months would also increase productivity and facilitate management.

DOA also has a vegetable and fruit research development centre in Hlegu, and DAR also undertakes research on the post-harvest aspects of horticultural production in the new Post-Harvest Institute (PHI) facility. Several horticulture research section staff were transferred to the PHI.

Given the very high level of private sector involvement in horticulture, and the large number of firms engaged in horticulture seed import and export, it will be very important to develop close linkages with between government research (DOA and DAR) and the private sector to identify and prioritize specific gaps where the public sector contribution is most valuable. Consideration should be given to establishing and scaling up private tissue culture facilities, with government facilities providing training services. This will allow government tissue culture facilities to focus on support for research while the private sector multiplies material for use by growers.

iv. Agronomy, Agricultural Economics and Agricultural Statistics Division

The Agronomy, Agricultural Economics and Agricultural Statistics Division is comprised of three research sections. The agronomy research section is conducting research on the potential to increase cropping intensity in rice-based cropping systems, evaluating optimal time of planting for newly released rice varieties, and conducting research on planting method and seed rate for rice. Agronomy research section activities are focused almost entirely on lowland cropping systems due to lack of staff and access to an upland research farm. The agronomy research section has only 3 MS level staff. Given the importance of agronomy for the integration of improved germplasm into climate resilient and profitable cropping systems for multiple agro-ecological zones it is critical to strengthen research capacity in this area.

The agricultural economics and agricultural statistics research sections are very small at present. The agricultural economics research section had only one MS scientist until recently, but two junior MS level staff have now joined the section and are being mentored in their new roles. The unit is mainly involved in studies in collaboration with international or regional institutes from Australia, Japan and Singapore. The agricultural statistics research section does not collect any of its own data, depending on secondary information from DOA for variety adoption by crop over time. The data is not reliable enough to provide useful analysis to guide research activities.

There is currently very little integration between either of these sections and the research activities of the biological sections. The integration of socio-economic analysis into biological research activities would be very helpful for evaluating the profitability of new techniques, a major factor affecting whether farmers will adopt them. It is essential to know, for example, whether the benefits of insect or plant disease control outweigh the costs prior to making recommendations. An expansion of capacity in agricultural economics will also be very important for strengthening engagement with farmers and agribusinesses through regional research centers, and for monitoring adoption of improved varieties and practices. The agricultural economics and statistics research sections could conveniently be combined to support decentralized regional research centres in carrying out such tasks.

v. Soil Science, Water Utilization and Agricultural Engineering Division

The Soil Science, Water Utilization and Agricultural Engineering Division consists of three research sections. The soil science research section conducts research on soil fertility maintenance and fertilizer management to increase crop production using environmentally friendly and soil health promoting techniques. The section is undertaking research to move beyond nationwide to region and soil-type specific fertilizer recommendations for major crops. The section also screens varieties for adaptation to important soil quality problems. The section is home to the Soil and Plant Analysis Laboratory (SPAL), a reference soil laboratory taking part in the harmonization and standardization of laboratory quality assurance and quality control as part of the South East Asia Laboratory Network organized by the Food and Agricultural Organization of the United Nations (FAO).

The water utilization research section is studying the effect of different water management regimes for rice, groundnuts, maize, sesame and tomato. Experimental treatments differ by crop. For rice the section looks at the water requirements, fuel and labor costs, and methane emissions of different water management regimes, as well as the interaction between water management regimes and slow release nitrogen on rice yield components. For groundnuts, the section is looking at combining different supplementary irrigation practices with drought resistant cultivars. For maize, conventional and zero tillage are compared with mulching and frequency of irrigation. For sesame, the effect of frequency of irrigation on yield and yield components for the pre-monsoon crop in irrigated areas is being studied.

The agricultural engineering research section develops and/or tests small-scale farm equipment (e.g., plough, weeder, seeder, harvester, thresher). The section also conducts research on improved irrigation techniques to expand options to adapt to climate change.

vi. Biotechnology, Seed Bank, Plant Protection and Microbiology Division

The Biotechnology, Seed Bank, Plant Protection and Microbiology Division consists of three research sections and the Seed Bank (which also conducts research). Biotechnology is a critical resource for accelerated plant breeding. The current biotechnology research section is extremely constrained by shortage of staff and budget. There are only 2 PhD and 2 MS level staff, and the annual operations budget is just $15,000. Marker Assisted Selection (MAS) could help accelerate the identification of improved germplasm for several crops (e.g., maize, hybrid rice, black gram, groundnut, and mango), but only rice and tomato currently benefit from MAS techniques due to lack of human resources, equipment and recurrent budget. The section also applies a range of tissue culture methods in support of crop improvement for rice, sugarcane, oil palm, mango, coffee, banana, potato and sweet potato, and orchids.

The Department of Agriculture has a much larger biotechnology capacity which is exclusively focused on rice. YAU also has significant capacity in molecular biology but there is no collaboration at present with DAR. Collaboration with advanced research institutes is also limited due to the lack of a biotechnology law and biosafety framework. The contribution of biotechnology to improved varieties could be greatly increased by strengthened collaboration among the different units in Myanmar and with international research institutes. Because of the difficulty in achieving collaboration across Departments and across Ministries, consideration should be given to the creation of a single plant biotechnology center under the management of DAR.

The seed bank is a valuable resource for Myanmar, with approximately 13,000 local accessions. It is well staffed and professionally managed. The seed bank does not provide services to DAR's breeding sections for the conservation of either released varieties or parent lines. This is a missed opportunity for collaboration since the gene bank still has one third of its storage capacity not yet utilized. Breeders' seed for a number of released varieties is no longer available in Myanmar due to lack of access to the gene bank storage facilities.

The entomology research section collaborates with crop improvement research sections to identify resistant cultivars for the major insect pests affecting rice, groundnut, chickpea, pigeonpea and cotton. The relevant pests are plant hoppers, yellow stem borer and gall midge for rice, pod borer for pulses, sucking pests for cotton, and leaf miner and binder for groundnut. The unit also investigates biological pest control methods. The section has one PhD and one MS level researcher. Given the heavy investment by farmers in chemical pesticides, often applied without protective equipment, the public investment focus on resistance and natural control methods is very appropriate.

The plant pathology research section collaborates with crop improvement research sections to evaluate disease resistant varieties and identify control measures. For rice, the section screens for resistance to BLB),Bacterial Leaf Streak, Blast and Sheath Blight; for maize, Banded Leaf and Sheath Blight and Turcicum Blight; for green gram, Cercospora Leaf Spot and Yellow Mosaic Virus; for sesame, Black Stem; and for Sugarcane, Red Rot. The section has 1 PhD and 5 MS level staff. A further two staff are enrolled in PhD training and one in MS training at YAU.

vii. Central and Satellite Farms

DAR's network of central and satellite farms is a critical component of its research capacity (Figure 2). It provides the capacity for evaluating germplasm and improved crop management techniques under a range of environments, as well as multiplication of early generation seed. Each farm has specific "mandate crops" (see Annex 2 for more detail). Engagement with local farming communities and extension workers is limited to field days held on the farm.

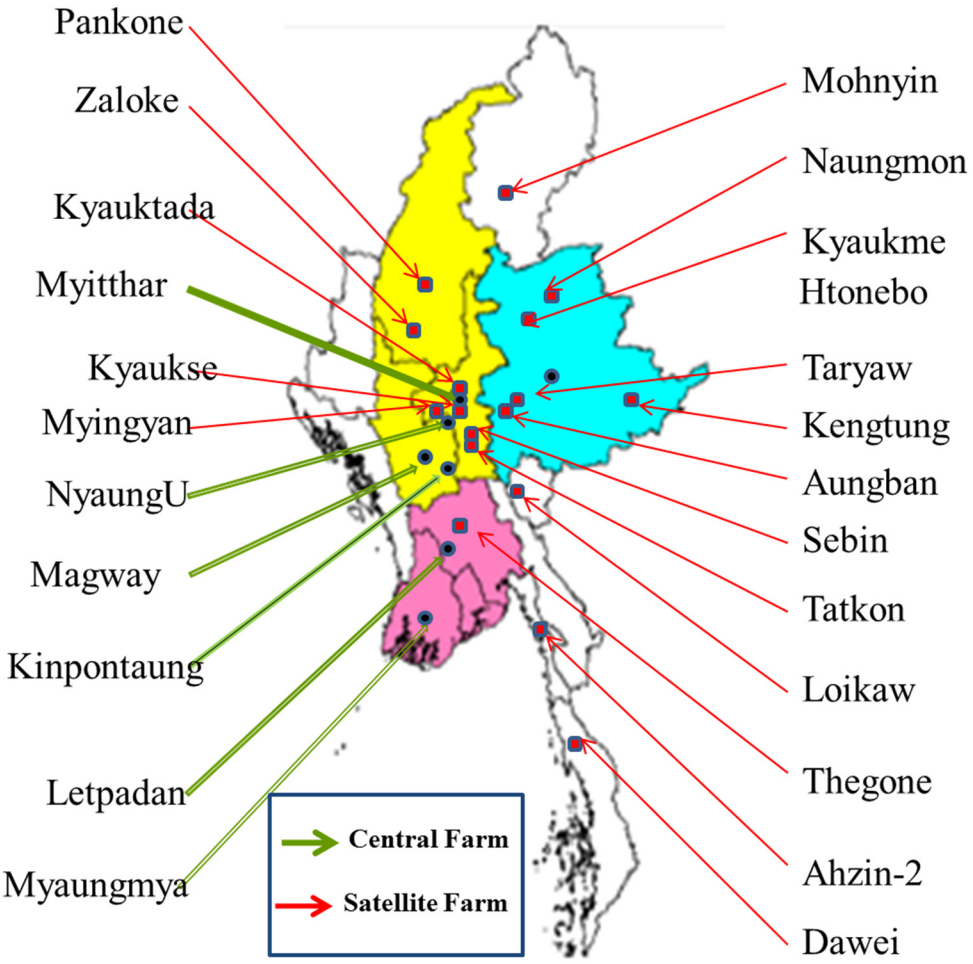
Most satellite farms visited as part of the evaluation face significant constraints in terms of staff and equipment. They are also expected to generate revenue from the production and sale of seed. This results in an over-emphasis on seed production relative to research activities. Furthermore, seed production emphasizes varieties that farmers already know rather than new varieties they are less familiar with (to avoid the risk of unsold stock).

From a research perspective, the central and satellite farms are an under-utilized resource. With appropriate (multi-disciplinary) staffing and cropping systems mandates, they could play a vital role in identifying research priorities for the major cropping systems in their respective areas, and communicating this to HQ-based researchers. They could also engage more closely with extension workers to design and implement on-farm trials and demonstrations in response to the needs and priorities of local farming communities.

Expanded engagement by satellite farms with local farming communities, along with the participation of local agribusinesses who supply farmers with inputs and buy their produce, could accelerate the identification and dissemination of improved technologies. DAR has taken the innovative step of establishing a pilot decentralization activity, the Sagaing Regional Research Centre, to evaluate this kind of approach. Led by the Zaloke satellite research farm, in collaboration with the Sagaing Region DOA extension staff, and supported by DAR Yezin mobile

teams, a series of on-farm trials and demonstrations are underway in 12 villages in response to problems jointly diagnosed with, or interests expressed by, farmers themselves. The approach will be scaled out to additional RRCs in the coming years. Eventually the mandate should be expanded to include livestock and aquaculture as well as cropping systems.

Figure 2: DAR Central and Satellite farm locations



Source: DAR

viii. M&E System

DAR has a regular system of reporting on progress of implementing research activities. Updates are sent every two weeks to MOALI. Results of DAR research activities are presented at the annual research and extension meetings held in Yezin in late April or early May. The DOA reports information on the extent of adoption of improved varieties but there is little information on the methods used or the reliability of the data. As a consequence, DAR has no access to a statistically rigorous system of monitoring adoption of improved varieties and practices that could inform research priorities or planning of EGS requirements. Measurement of adoption is made even more difficult by the fact that many officially released varieties are labelled Yezin followed

by a sequence number (e.g., Yezin 6). Farmers also assign local names to improved varieties. There is no repository for information on variety demonstration activities by DOA and DAR, making it difficult to even plan adoption studies. This makes it impossible to either 1) use feedback from variety dissemination efforts to adapt dissemination campaigns, or 2) demonstrate the financial and economic benefits of research to Myanmar farmers and consumers. Monitoring adoption of improved varieties is a critically important task that DAR's agricultural statistics and agricultural economics sections should focus on in collaboration with regional extension services.

CRITICAL REFORMS AND INVESTMENTS

The review of DAR's research activities presented above shows that major increases in the number of scientists and the level of budget allocation is clearly necessary. But to accelerate the identification and dissemination of improved technologies, changes are also required in the way research is organized.

The main output of DAR's research is improved varieties. This is an appropriate focus given the very small size of the research system and the potential for taking advantage of germplasm from the CGIAR centers and neighboring country research institutes. DAR's effectiveness in screening and testing improved varieties could be greatly increased, however. Specific steps to achieve this goal include first, at HQ level, the integration of biotechnology and plant breeding through expanded use of marker assisted selection techniques[5]. This will require a much larger number of biotechnology scientists, with more modern equipment, and fully integrated into a unified genetic improvement program.

Biotechnology and plant breeding programs should be consolidated to overcome the current fragmentation. In the case of agricultural biotechnology, for example, the programs of DAR, DOA, YAU and the Ministry of Education's Department of Science and Technology should be amalgamated, even if they remain in separate facilities in the near term while infrastructure is upgraded. The hybrid rice and open-pollinated rice research sections should also be amalgamated. Finally, it is essential that the Seed Bank conserve seed of all released varieties and parent line materials (along with related materials with desirable resistant traits), that could be deployed in the event of a popular variety succumbing to a biotic stress. The current Seed Bank policy of only conserving local accessions is a significant risk for DAR as the breeding programs do not have adequate germplasm storage facilities.

A second step to increased effectiveness requires the rapid expansion of multi-location testing of improved plant materials, with wide-scale on-farm testing at an early stage in collaboration with DOA extension. An effective communication channel to provide feedback from farmers and traders is essential to identify "winners" and screen out "losers". Finally, seed multiplication should focus on early generation seed of new varieties and make it available to the private sector and farmer seed producer SMEs as quickly as possible for further multiplication and distribution. In summary, given that improved varieties is the main output of DAR's programs at the present time, attention must be given to accelerating the identification of superior material, scaling out its evaluation, and rapidly scaling up the availability of improved varieties to farmers.

[5] Currently only the rice and horticulture research sections of DAR benefit from MAS techniques.

At present, most DAR crop management research is focused on improving productivity at the plant or parcel level, not at the cropping system level. Given DAR's emphasis on crop variety development, it is important to enable farmers to exploit their potential in the context of farmers' cropping systems. New varieties often provide the opportunity for new multiple cropping or inter-cropping patterns. Optimum soil, agronomy, water and pest management strategies all depend on the cropping system environment. The profitability of cropping systems depends on markets, and the input and product prices farmers face. This implies that socio-economics needs to be an integrated science alongside biological sciences. Just as DAR's crop breeding programs will benefit from expanded and closer integration with biotechnology capacity, so too will a unified approach to cropping systems management benefit the identification and testing of the most profitable systems in which farmers deploy new varieties.

As in the case of plant breeding, an effective cropping systems program will depend on expanded and strengthened multi-location testing. This in turn means that a much larger number of MS and PhD scientists need to be deployed to DAR's crop research centers and satellite farms outside Yezin. Instead of having mandates for individual crops, research farms in a given agro-ecological zone (AEZ) should work on the predominant cropping systems in their area. Farmers and private sector companies buying their produce should be closely involved in identify the main constraints they face. Resident socio-economic staff will be needed to help evaluate the profitability of improved technologies and/or the market factors (market or consumer preferences) influencing adoption. Social scientists should also help to monitor adoption (or dis-adoption) closely to help inform the design of research activities and help DAR justify higher budgets. Because it will be impossible for every group of satellite farms to have resident research specialists in every field, HQ mobile teams should be formed who will visit satellite farms at least once during a cropping season.

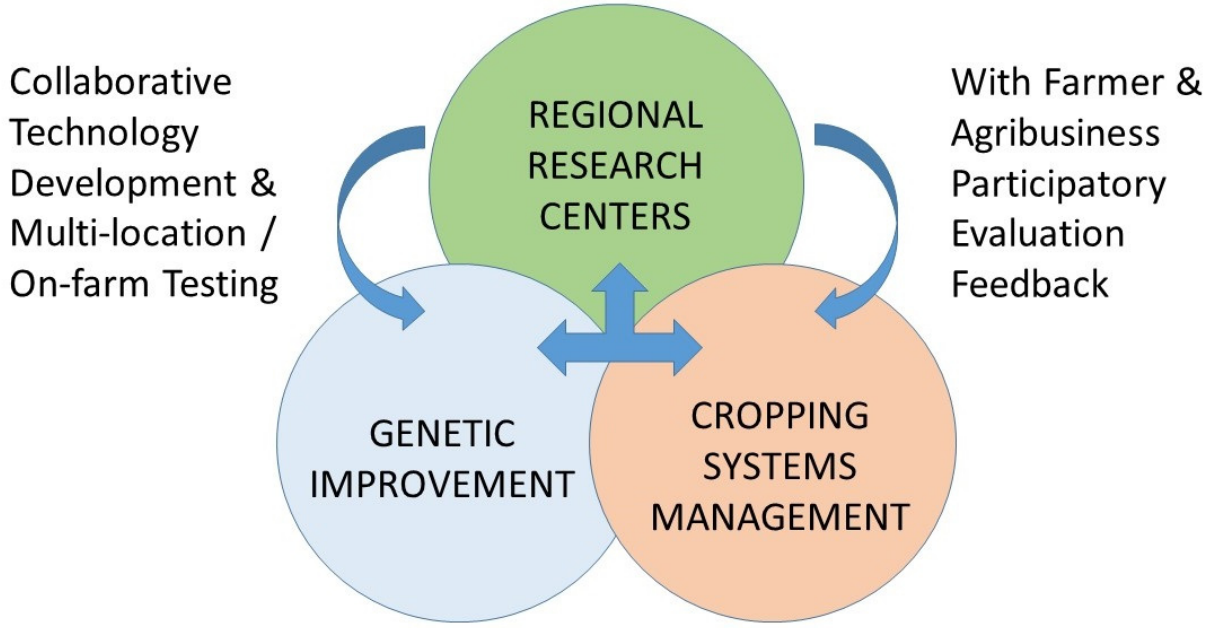
The development and adoption of improved varieties, cropping systems and crop management practices will take place more rapidly if undertaken in close collaboration with farmers and agribusiness companies. This can only occur through a decentralized approach where farmers and agribusinesses can interact with research and extension through on-farm research activities. DAR's network of satellite farms provides the basic infrastructure for such a decentralized approach, especially if activities are coordinated with DOA farms, but there are currently very few researchers with graduate training located at these sites. The lack of graduate research training, limited exposure to farmer clients due to transport and budget constraints, and a tradition of hierarchical decision making, makes it difficult for staff at satellite research stations to participate in research prioritization and design. The expectation that central and satellite farms generate revenue from seed production is a distraction from their primary role of research and early generation seed for multiplication by the private sector.

A research system that combines modern crop breeding approaches, cropping systems design and close engagement with farmers and the private sector requires a very different approach to organization and planning than the current system. Figure 3 illustrates how the system could be organized to reflect the three major tasks of identifying improved germplasm, more productive cropping systems, and farmer and agribusiness client engagement. The current 6 technical divisions and 20 research sections in Figure 1, together with the central and satellite farms, could be re-organized into 3 inter-linked programs as shown in Figure 3.

A Genetic Improvement program would include all current crop variety research sections from the existing divisions, as well as DAR, DOA and YAU biotechnology units and the DAR seed

bank. A Cropping Systems Management program would include all other DAR technical research sections, as well as economics and statistics research sections. The Regional Research Centers would be the current central and satellite farms in Figure 2, grouped by agro-ecological zone, and supported by HQ specialist (mobile) teams similar to the current Sagaing RRC pilot program. Each RRC program should have a resident agricultural economist as part of the multi-disciplinary team. See Annex 3 for more details on the composition of each program.

Figure 3: Approach to DAR Program Design and Management



It is important to note that the above approach to program design could be implemented immediately even without (or before) a structural re-organization. For this to occur a program design leadership team comprised of three Program Coordinators would need to be identified, working under the direction of a Deputy Director General.

NEXT STEPS

The current underinvestment and lack of research capacity is a significant threat to Myanmar's agricultural productivity and the future wellbeing of Myanmar citizens, especially in rural areas. The Agricultural Development Strategy provides an opportunity to correct this situation and ensure that the full potential of Myanmar's future harvest is realized.

The following actions are recommended to improve public sector research effectiveness quickly and in ways that are consistent with the long-term development of the NARES:

1) Establish an agricultural research and extension strategy development leadership team, from all MOALI units with research mandates and activities, to oversee the preparation of an agricultural research and masterplan for the ADS. Initial tasks will include:
    a. Prepare an inventory of human resources with advanced research degree training across MOALI and their current functions;
    b. Re-assign any staff with recently completed advanced research degrees who are currently performing administrative or project management functions to research activities;
    c. Develop a consolidated advanced research degree training program and budget;
    d. Develop a performance-based research career progression with financial and non-financial incentives to retain trained capacity in research functions;
    e. Ensure that the Technical Seed Committee and National Seed Committee meet regularly to evaluate submissions for the release of improved varieties;
    f. Explore potential for expanded licensing of publicly owned hybrids and OPV/SPVs to the private seed sector to accelerate commercialization and access by farmers.
    g. Undertake a preliminary analysis of expected increase in value of agricultural output from research on majors crops, livestock, aquaculture and farming systems to guide research investment allocation;
    h. Publish a single MOALI five year agricultural research and extension plan and budget with specific targets for release/dissemination and adoption;
    i. Publish an annual report on agricultural science accomplishments and impact at farm level.

2) Organize research planning, budgeting and M&E according to three main programs: 1) Genetic Improvement; 2) Cropping Systems Management and 3) Regional Research Centers. As livestock and aquaculture capacities are established they can be integrated so that program 2 becomes Production Systems Management and program 3 becomes Farming Systems Development. The purpose of program 1 is to identify or develop improved varieties (and livestock breeds) adapted to Myanmar's markets and agro-ecologies. The purpose of program 2 is to identify or develop more efficient production and post-harvest management practices for cropping systems (and livestock and aquaculture management). The purpose of program 3 is to engage farmers and agribusinesses working on all major farming systems in the country in the identification of problems, testing of improved technologies developed or adapted by programs 1 and 2, and develop plans for scale-up with extension services. Each of the three main programs would have sub-programs that collaborate on shared objectives with efficient use of shared resources such as biotechnology (see Annex 3 for details);

3) Undertake expert technical reviews for each main program and sub-program to identify priority genetic or production management improvements to be achieved, and potential pest and disease threats to be countered, for Myanmar's major production systems over the next five years;

4) Accelerate progress in crop breeding by forming a critical mass of researchers and facilities in breeding and biotechnology working together on priority crops or species in combination with international advanced research institutes (pending organizational re-

structuring, one MOALI Department should be given lead responsibility for managing each cluster);

5) Prepare a biotechnology policy, law and safety framework to maximize the potential for the safe acquisition and deployment of biotechnology innovations that can benefit farmers and consumers;

6) Accelerate and expand geographical coverage for the testing and dissemination of improved varieties/species and/or management practices at farm level through collaboration between research and extension resources of MOALI at regional level and focusing effort on early generation seed multiplication of pre-lease materials;

7) Strengthen regional level research and extension activities through multi-disciplinary teams, including socio-economists to help monitor the impact of adoption of improved genetic materials and techniques;

8) Engage local private sector operators, such as seed companies, agricultural traders and processors, in the identification and promotion of promising genetic materials and techniques;

9) Accelerate variety and product registration and release procedures for public and private sector technology providers; and

10) Privatize and ensure independent quality control of non-research functions such as tissue culture, non-early generation seed multiplication, breeding stock production, or production of soil health materials.

Responsibility for development of an integrated research and extension system will eventually be vested in a National Agricultural Research Council guided by agricultural research and extension policies. Nevertheless, implementation of the steps outlined above could be begin immediately.

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ANNEX 1. DAR RESEARCH TASK FORCE MEMBERS

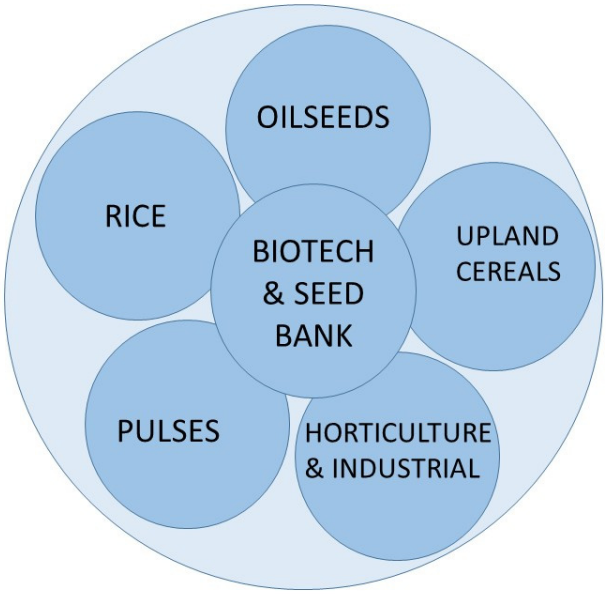
Sr. No.	Name	Position	Department/Division/ Section
1.	U Naing Kyi Win	Director General	Department of Agricultural Research
2.	Dr. Su Su Win	Director	Soil Science, Water Utilization and Agricultural Engineering Division
3.	Dr. Tun Shwe	Director	Food Legumes and Oil Seed Crops Division
4.	Dr. Min San Thein	Senior Research Officer	Seed Bank
5.	Dr. Aung Moe Myo Tint	Senior Research Officer	Maize and other Cereal Crops Research Section
6.	Dr. Mar Mar Win	Assistant Research Officer	Food Legumes Research Section
7.	Dr. Ni Ni Tint	Research Officer	Industrial Crops Research Section
8.	Dr. Ohn Mar Saw	Assistant Research Officer	Seed Bank
9.	Dr. Pau Siam Kam	Research Officer	Planning and International Relation Section
10.	Dr. Thida	Assistant Research Officer	Biotechnology Research Section
11.	Dr. Myat Thaint Ko	Assistant Research Officer	Horticultural Crops Research Section
12.	Dr. Thi Thi Aung	Senior Research Assistant	Plant Pathology Research Section
13.	Dr. Aung Kyaw Thu	Senior Research Assistant	Water Utilization Research Section
14.	U Htin Kyaw	Senior Research Assistant	Oil Seed Crops Research Section
15.	Daw Thaingi Myint	Senior Research Assistant	Horticultural Crops Research Section
16.	Daw Thi Thi Soe Hlaing	Senior Research Assistant	Planning and International Relation Section
17.	U Nay Aung	Senior Research Assistant	Maize and other Cereal Crops Research Section
18.	U Myo Thwin	Junior Research Assistant	Rice Research Section

ANNEX 2. CURRENT MANDATE CROPS FOR DAR SATELLITE FARMS

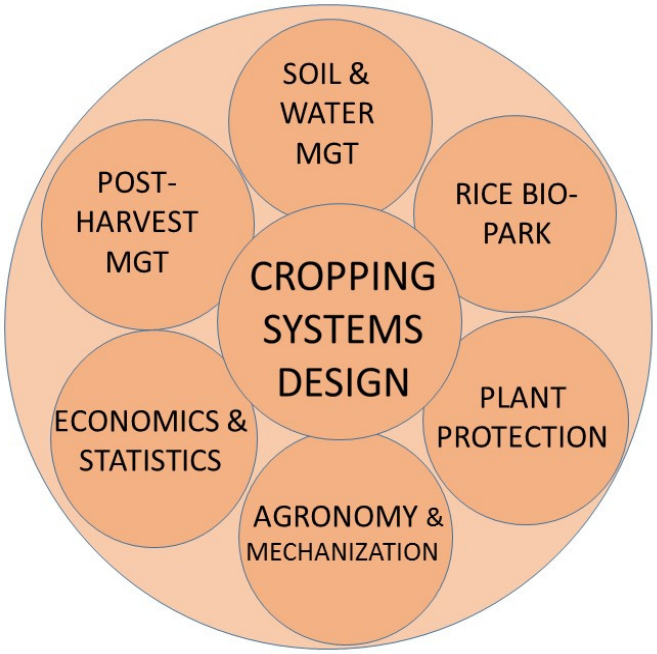
Sr. No.	Regions	Mandate Crops
1.	Mohnyin	Rice, Soybean, Mustard (oil)
2.	Naungmon	Maize, Soybean, Upland Rice, Wheat, Coffee
3.	Kyaukme	Maize, Soybean, Upland Rice, Wheat, Tea
4.	Aungban	Vegetables, Wheat, Maize, Soybean, Canola and Niger
5.	Htonebo	Culinary, Vegetables
6.	Taryaw	Rice, Sunflower, Garlic
7.	Loikaw	Rice, Soybean, Sunflower, Culinary, Maize
8.	Azin 2	Fruits, Rubber
9.	Htarwae	Rubber, Oil Palm, Fruits
10.	Myangmya	Rice, Fiber Crops, Blackgram, Greengram
11.	Thekone	Rice, Greengram, Blackgram
12.	Letpadan	Rice, Greengram, Blackgram
13.	Magway	Sesame, Groundnut, Greengram, Pigeon Pea
14.	Kinpontaung	Sugarcane, Rice, Blackgram
15.	Naung U	Oilseed Crops, Pulses, Sorghum
16.	Myingyan	Pigeon Pea, Chickpea, Sorghum
17.	Kyaukse	Rice, Chickpea, Mango
18.	Kyauktada	Rice, Groundnut, Mango
19.	Myittha	Cotton, Rice, Chickpea, Onion
20.	Zaloke	Wheat, Chickpea, Pulses
21.	Pangone	Rice, Wheat, Chickpea
22.	Sebin	Pulses, Sunflower, Cotton
23.	Tatkon	Maize, Sunflower, Greengram, Vegetables, Culinary
24.	Kengtung	Rice, Maize
25.	Maeaungkan	Rice, Mango, Grape, Plum

ANNEX 3. PROPOSED RESEARCH PROGRAM COMPOSITION

Genetic Improvement Research Program



Cropping Systems Management Program



Regional Research Centres Program