Livelihoods and Food Security Trust Fund /UNOPS

Water Resources Utilization Department

ADRA (Adventist Development and Relief Agency)

Initial Feasibility Assessment of Water Pumping and Irrigation Schemes in the Arid/Dry Zone of Myanmar

MAIN REPORT

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Acronyms

ADRA	Adventist Development and Relief Agency
AED	Agriculture Education Division
AMD	Agriculture Mechanization Department
CARI	Central Agricultural Research Institute
CARTC	Central Agricultural Research and Development and Training Centre
CBM	Central Bank of Myanmar
CBO	Community-based organization
CDZ	Central Dry Zone
CIRDAP	Centre for Integrated Rural Development for Asia and the Pacific
CWR	Crop Water Requirements
DAP	Department of Agricultural Planning
DAR	Department of Agricultural Research
FAO	Food and Agricultural Organization
FSATG	Food Security and Agriculture Thematic Group
FSWG	Food Security Working Group
ID	Irrigation Department
INGO	International non-Government organization
JICA	Japan International Cooperation Agency
LIFT	Livelihoods and Food Security Trust Fund
LUD	Land Use Division
MADB	Myanmar Agricultural Development Bank
MAS	Myanmar Agriculture Service
MICDE	Myanmar Industrial Crop Development Enterprise
MOAI	Ministry of Agriculture and Irrigation
MOLF	Ministry of Livestock and Fisheries
NGO	Non-Government organization
PIP	Pumped Irrigation Project
PONREPP	Post-Nargis Recovery and Preparedness Plan
TGFSA	Thematic Group for Food Security and Agriculture
UNCT	United Nations Country Team
UNDP	United Nations Development Programme
UNOPS	United Nations Office for Project Services
WFP	World Food Programme
WRUD	Water Resources Utilization Department
YAU	Yezin Agricultural University

Table of Conversions and Local Units

1 hectare	=	2.471 acres
1 kg	=	0.61 vis
1 vis (a measure of weight).	=	1.64 kg
1 basket (a measure of volume) of:		
Paddy	=	17 kg
Yellow gram (husked)	=	78.18 kg
Yellow gram (unhusked)	=	31.36 kg
Green gram	=	68.40 kg
Unhusked groundnuts	=	25.20 kg
Sesame	=	24.50 kg
Pigeon pea	=	33 kg
Wheat	=	72 kg
Sunflower	=	13.1kg
Red bean	=	72 kgs

Length

1 inch (in)	0.0254 m
1 foot (ft)	0.3048 m
1 yard (yd)	0.9144 m
1 mile	1609.344 m
1 metre (m)	39.37 inches (in)
1 metre (m)	3.28 feet (ft)
1 metre (m)	1.094 yards (yd)
1 kilometre (km)	0.62 miles

Area

1 square inch (in^2)	6.4516×10^{-2} m^2
1 square foot (ft^2)	0.0929 m^2
1 square yard (yd^2)	0.8361 m^2
1 acre	4046.86 m^2
1 acre	0.4046 ha
1 square centimetre (cm^2)	0.155 square inches (in^2)
1 square metre (m^2)	10.76 square feet (ft^2)
1 square metre (m^2)	1.196 square yard (yd^2)
1 square metre (m^2)	0.00024 acres
1 hectare (ha)	2.47 acres

Volume

1 cubic inch (in^3)	1.6387×10^{-5} m^3
1 cubic foot (ft^3)	0.0283 m^3
1 cubic yard (yd^3)	0.7646 m^3
1 cubic centimetre (cm^3)	0.061 cubic inches (in^3)
1 cubic metre (m^3)	35.315 cubic feet (ft^3)
1 cubic metre (m^3)	1.308 cubic yards (yd^3)

Power

1 Joule/sec	0.7376 foot pound/sec
1 foot pound/sec	1.3557 watt
1 cheval-vapor	0.9861 hp
1 Kcal/h	0.001162 kW
1 watt (W)	1 Joule/sec = 0.7376 foot pound/sec (ft lbf/s)
1 horsepower (hp)	745.7 watt 550 ft lbf/s
1 horsepower (hp)	1.014 cheval-vapor (ch)
1 kilowatt (kW)	860 Kcal/h = 1.34 horsepower

Capacity

1. imperial gallon	0.0045 m^3
1. US gallon	0.0037 m^3
1. imperial barrel	0.1639 m^3
1. US. barrel	0.1190 m^3
1 pint	0.5681 l
1 US gallon (dry)	0.0044 m^3
1 litre (l)	0.22 imp. gallon
1 litre (l)	0.264 U.S. gallon
1 litre (l)	0.0061 imperial barrel
1 hectolitre (hl)	100 litres = 0.61 imperial barrel = 0.84 US barrel
1 litre (l)	1.760 pints
1 cubic metre of water (m^3)	1000 l = 227 U.S. gallon (dry)
1 imperial barrel	164 litres

Mass

1 ounce	28.3286 g
1 pound	0.4535 kg
1 long ton	1016.05 kg
1 short ton	907.185 kg
1 gram (g)	0.0353 ounces (oz)
1 kilogram (kg)	1000 g = 2.20462 pounds
1 ton	1000 kg = 0.984 long ton = 1.102 short ton

Energy

1 B.t.u.	1055.966 J
1 foot pound-force	1.3559 J
1 B.t.u.	0.25188 Kcalorie
1 B.t.u.	0.0002930 KWh
1 Joule (J)	0.000947 B.t.u.
1 Joule (J)	0.7375 foot pound-force (ft.lbf)
1 kilocalorie (Kcal)	4185.5 J = 3.97 B.t.u.
1 kilowatte-hour (kWh)	3600000 J = 3412 B.t.u.

Currency Equivalents

Currency		**Equivalent**
US$ 1.00	=	Kyats 750
Euro 1.00	=	Kyats 850

Figure 1. Map of Myanmar

Executive Summary

Past efforts to engage the government in improved technical approaches have not gained much support as they have tended to be too overarching and requiring too much change into too short a time. The approach adopted in this mission towards improvement of the pumped irrigation projects (PIP)[1] is seen to be appropriate in the light of lessons learned and considering the receptiveness of the WRUD partners. There is no doubt that there is change taking place within the development thinking in Myanmar, but there is still resistance to change in many areas. Those dealing with service provision to the farmers, especially at the top level in government in Naypyidaw, find it difficult to move easily from the command to the farmer driven approach. In the field, changes are already being realised particularly in the range of crops that are actually being grown. This is noticed more on PIPs where it is recognised that many of the soils assumed suitable for production of paddy rice cannot be utilised in this way. Resultant water delivery shortages and insufficient moisture availability within the soils have led to a greater range of crops being cultivated. Policy crops still dominate where feasible (except for cotton) but these are no longer being pushed on the less suitable soils. There is thus a manifested willingness to adopt a more flexible approach in the selection of crops, but many planners and implementers are not familiar with free-market driven approaches and the need to examine cost-effective solutions.

Within WRUD, both at Central and Regional/District level, there is a strong interest to improve upon current poor performances. Many have recognised the need to improve planning, design and implementation and to overcome the deficiencies in past approaches. There is an openness to discuss these issues, which the mission has been advised is an unusual and very positive movement, and an awareness of the need to involve farmers much more inclusively in all aspects of the project cycle. However, there is little experience within WRUD of the softer aspects of such approaches but they are willingly looking for experienced advice and support to enable them to introduce effective measures to move towards improved food security and food production.

This technical report has been prepared following the visit to Myanmar of a technical mission funded through the Livelihoods and Food Security Trust Fund (lift). It visited 7 PIP sites in the central dry zone that were considered as representative of WRUD interventions. On conclusion, the mission held a series of debriefing meetings with WRUD[2] and the Ministry of Agriculture and Irrigation (MOAI)[3]. An informal debriefing was also held with fund board representatives before the final debriefing presentation.

This final report has been produced by the Consultants represents their analysis of the technical situation in the field and the scope for improving productivity with the goals of greater food security and improved family livelihoods and village level. It expands upon the preliminary findings, conclusions and recommendations presented in the debriefing presentations that were summarised in the aide memoire. It has been formulated by examining the existing situation through “new eyes” on the technical problems faced with the overall aim being to increase the overall productivity from the PIP. The main issues of concern have been highlighted and the suggested areas for improvement identified. These are presented briefly below.

The design approaches seen on all 7 pumped irrigation projects were similar and used standard designs. Implementation had been construction driven and geared towards increasing the area under policy crops. However, no feasibility studies were carried out as the designs were implemented very quickly and from an engineering viewpoint that had little agricultural input. This resulted inadequate adaption to field conditions and water delivery unrelated to soils and suitable crops that could be grown. In many places, the on-farm network (tertiary canals and watercourses) had not been completed and although attributed to the poor response of farmers, it would appear that these resulted from little to no consideration to how the on-farm network would connect with the primary network and what

[1] That represent about 10% of the irrigated command area in Myanmar
[2] The Director-General and senior staff.
[3] The Deputy Ministers for Agriculture and Irrigation and selected senior staff from the Planning Departments

resources would be needed to achieve this.

Although paddy is the most common crop in Myanmar, in CDZ where many soils are lighter and derived from sandstone, oilseed crops, groundnuts and other cash crops more suited and are commonly found. Farmers in these areas are unfamiliar with irrigation, relying solely on rainfed conditions. Furrow irrigation methods are more suited to these crops on these more permeable soils but furrow irrigation is not common and thus the design engineers and farmers are not familiar with the technique. Examination of the design processes has shown that many WRUD Engineers do not have appropriate irrigation and drainage design experience. This results from a lack of basic training in this subject, the institutions from which they graduated produce civil/construction engineers, and a lack of practical and relevant field experience.

Canal structures have been based on proven designs that have worked well and whose construction is within the capacity of local masons. Pump stations and canal conveyors (main canal; distributary canal;) have been in most cases well designed and built but as the designs are based on water duty, the only provide the maximum design discharge for the canals and pumping units, not the variations over the season. This is not sufficient to facilitate proper scheduling of water supply in relation to meeting varying crop water demands or to adjust supplies following rainfall. Pump operators endeavour to adjust the pumping needs of the farmers by pumping as long as is possible with the budgets available and when electricity supply is not interrupted. This only secures water to those farms located on the less permeable soils and closer to the supply canals and results in over irrigation at certain times of the year. This is evidenced by accumulation of water in low-lying areas and drainage canals. Without any measuring structures, it is not possible to determine accurately how much is being pumped and whether needs being met and so the approach is hit and miss.

Many PIPS are only part utilised due to technical and sandy soil problems and cropping intensities achieved vary from 83% up to about 133%. This is small compared to the relatively high investment and what should be achievable on such schemes. Net returns achieved by those farmers receiving water are around 10 to 20% less than those received by farmers for similar crops on gravity irrigation schemes. This is not only due to the cost of pumping, but also to the very low water charges on the gravity schemes. Average yields of paddy are low and are principally constrained by irregular water supply and a lack of improved seed. Farmers are acutely aware of this but lack access to it. If improved seed is not delivered concurrently with the provision of irrigation and drainage facilities, then the benefits attributed to irrigation are considerably reduced.

Another main constraint is farm advisory services that are largely ineffective. Significant changes in approaches are needed with improved direct involvement with the farmers, such as through farmers' field schools, and significant improvements in training of extension staff and implementation of training for Lead Farmers.

As water charges are insufficient to meet operation and maintenance costs and government allocations are very low, limited maintenance is carried out on the PIPs. There is a need to increase the contributions to maintenance to avoid the systematic "mining" of the infrastructural assets that have deteriorated further over time. At design, limited attention is paid to the management, operation and maintenance (MOM) of PIPs with no measuring structures included, no scheduling of water supplies and minimal actual involvement in the decision-making by the farmers. Water users associations exist on operational irrigation schemes visited. By working with them and ensuring that they are well informed and involved in all aspects of scheme development, larger contributions to funding O&M can be obtained scheme operational losses reduced. One major problem is that formation of the WUAs awaits scheme completion and no attempts are made to prepare the farmers for their involvement. This needs to be addressed from as early as the design stage so that full planned benefits are achieved and that designs "fit" in the field.

When the development cost per hectare are reviewed, 6 of the PIPs have costs less than US$ 5,000/ha which would be considered as an appropriate cut-off rate for viable projects so long as all costs have been included. However, as on many schemes, tertiary and on-farm costs have not been included, a number of the PIPs would be considered marginal investments. The viability has also been significantly affected by the considerable delays in achieving benefits that could not come on-stream until the main and secondary systems have been completely finished and have been further delayed by delays in the construction by the farmer groups of the tertiary and watercourse systems.

In conclusion, the field assessment has shown a range of areas in which considerable improvements can be achieved and thus a range of possibilities for jointly[4] supporting interventions to improve the outputs from the PIPs. With more attention being paid to the appropriate delivery of water to the farmer, through engineering improvements, improved water delivery, agricultural support to the farmer and the more direct involvement of the farmers through the strengthening of water users associations. Through this greater farmer involvement in decision-making, significant increases in returns can be realised for all crops on all soils in both seasons. However, this will only be achieved through the better selection of the crops to be grown in relation to soil types and market demands and the improvement of extension support and seasonal credit to farmers to enable them to provide the correct inputs in a timely manner.

The overall aim must be to get more crops per drop of water with water pumping rate related to crop water demand. Operational losses and energy costs need to be reduced. Although through this approach benefits will be achieved in the monsoon season, the greatest benefits will accrue in the summer season when many farmers within the PIP command areas are currently unable to access irrigation. It has been estimated that this will raise the overall average cropping intensity from less than 100%, to around 160%. If this is achieved, which is feasible in the shorterm, production for average to poorer farmers will be raised and have significant benefits in food security and livelihoods.

The field assessments and subsequent analyses have shown that the initial significant scope for improvement is in the selection of crops and cropping patterns and input availability that will have an immediate improvement on yields. Returns to labour for monsoon and summer paddy rice are low. Groundnut, high-value horticulture (HVH), sunflower and summer paddy become the interesting crops in the future. Opportunities exist for changing crops towards those with higher margins, that could not be grown before irrigation was provided, and this is confirmed by the financial analyses (B/C ratio; IRR) carried out assuming a 12% discount rate and a period of 20 years. These illustrate the impact of the proposed changes that raise the B/C ratio from about 1.0 under the existing situation, to around 1.7 in the improved short-term and 1.9 in the longer-term. The impact of delayed benefits and long construction period shows that the B/C ratio drops to 0.65 in this scenario.

Training institutions have no modules relating to irrigation and drainage and this needs to be addressed by the introduction of water management training and an irrigated agricultural program aimed not only at the higher levels within MoAI but also at the lower levels targeting WUA/farmer level training. A practical field-based training enhancement program needs to be developed that links with established training institutions both within the country and abroad. Several interesting initiatives are planned and if these are combined, will go a long way to improving skills of those involved in the design, implementation and management, operation and maintenance of the irrigation schemes.

The Consultants' proposals for support presented in Chapter 4 are aimed at achieving quick impacts over the next few years (3 to 5 years) but also at contributing to the longer-term sustainability of interventions. In the shorter timescale, the mechanism developed for LIFT trust fund would seem to be an appropriate means of supporting the softer interventions that the Donors have indicated they could consider supporting[5]. WRUD approaches have been engineering oriented and coupled with the lack of appropriate modules within the training institutions, has removed over time any links with the farmers and agriculture. Technical inputs/advice to support any proposed interventions will be needed and this could be achieved by providing a multidisciplinary group of well experienced senior experts, both short

[4] Donor and Government of Myanmar.
[5] The donor group has already indicated that at this stage it is not considering Investments in physical works.

and long-term, operating out of LIFT. These services would be provided to MOAI/WRUD/MAS and to NGO service providers. LIFT already has many NGO implementing partners dealing with communities within the dry zone and their skills could be extended to prepare them for the arrival of irrigation water. This will need common guidelines and training to ensure that appropriate and proven messages and approaches are adopted.

All of the proposals are aimed at initiating a useful dialogue between Myanmar and Donors on technical solutions to issues that relate to food security and livelihoods in the vulnerable Central Dry Zone. Government is aware that the softer aspects have been lacking from the past construction dominated interventions and is looking for practical proposals for encouraging such support to result from this mission. If this is achieved, it will assist considerably in the better planning and design of already initiated investments in pumped irrigation projects, and through this, stabilise production and contribute towards overcoming the impact of vagaries in rainfall in the dry zone.

During the visit to Myanmar and in the various discussions and debriefing meetings, it was emphasised that the outcome is not a foregone conclusion. However, WRUD has indicated that it is extremely keen on follow-up as soon as possible so that it has something to show to government on the way forward. This positive cooperation should be utilised whilst the opportunity exists. In conclusion therefore, it is considered as an opportune time for reassessing Donor involvement in irrigated agricultural developments within Myanmar, especially in the central dry zone areas, and entering into discussions with Government on how progress could be achieved. There is no quick fix solution but where there is willingness on both sides to improve relations on technical cooperation, there is no doubt that significant spin-offs in other areas can be achieved.

1. Introduction

A technical mission[6] funded through the Livelihoods and Food Security Trust Fund (lift) was fielded to Myanmar from 12 to 30 June 2011. Following briefings from trust fund board representatives and LIFT, the Consultants proceeded with the field assessment in the dry zone of Myanmar. Initial discussions were held with the Director-General of WRUD, the organisation responsible for pumped irrigation within Myanmar, and ADRA, the NGO with whom the mission had been organised by LIFT.

On 15 June, the mission travelled to Nyaung U and met with representatives from WRUD, MAS and ADRA and agreed upon the detailed mission itinerary and proceeded to the first sites. Over the next 10 days, the mission visited seven Pumped Irrigation Projects (PIP) sites, which were either under construction, part completed or fully completed and operational.

On conclusion of the site visits, the mission proceeded to Naypyidaw and held a series of debriefing meetings with WRUD[7] and the Ministry of Agriculture and Irrigation (MOAI)[8]. An informal debriefing was also held with fund board representatives before the final debriefing presentation[9]. In the Yangon, a meeting was held with FSAT group to inform them of the findings of the mission.

This final report has been produced following the departure of the Consultants from Myanmar. It elaborates further on the issues presented in the debriefing sessions and has been provided to LIFT within two weeks after leaving Myanmar.

1.1. Assignment

General terms of reference were provided for the mission to allow sufficient flexibility to enable the Consultants to assess the fully the scope of possible involvement. This Scoping Mission had the following general objectives:

- Assess the current situation with WRUD Pumped Irrigation Projects (PIP)
- Identify the constraints and type of assistance required to move forward
- Identify key issues affecting irrigation sector performance and suggest improvements to address these
- Assess the modalities for providing identified assistance.

It should be emphasised that without the considerable hands-on assistance from the Director-General, WRUD together with field logistics and support provided by ADRA and LIFT, it would not have been possible to complete the mission's objectives within the allocated time.

1.2. Approach

The majority of the pumped irrigation projects (PIP) developed by WRUD are contained within three dry zone regions of Myanmar namely Magwe, Mandalay and Sagaing. Within the time available, a programme was developed to visit representative examples of the projects at various stages of development within these regions. Seven sites were visited (Table 1) and on each of these sites discussions were held with:

- farmers from representative areas within project command area,
- WRUD project staff who were familiar with project implementation details and issues,
- MAS field staff, when available,
- Township leaders.

[6] Ian McAllister Anderson, Irrigation and Drainage Engineer, Team Leader and Tom Morrison, Agricultural Economist.
[7] The Director-General and senior staff.
[8] The Deputy Ministers for Agriculture and Irrigation and selected senior staff from the Planning Departments
[9] This PowerPoint presentation has been attached.

Table 1. Summary list of project sites visited

No.	Project Site (Pumped Irrigation Scheme (PIP)	Design Command area		Water Source	Location		
		Acres	Ha		Township	District	Region
1	Law Ka Nandar PIP	11,000	4,452	Ayeyarwaddy River-left bank	Nyaung U	Nyaung U	Mandalay
2	Lat Pan Che Baw PIP	1,500	607	Ayeyarwaddy River-left bank	Nyaung U	Nyaung U	Mandalay
3	Hnone Poe PIP	8,000	3,238	Ayeyarwaddy River-right bank	Pakokko	Pakokko	Magwe
4	Kyaw Zi PIP	8,000	3,238	Ayeyarwaddy River-left bank	Myingyan	Myingyan	Mandalay
5	Simeekone-3 PIP	15,000	6,070	Ayeyarwaddy River-left bank	Natogyi	Natogyi	Mandalay
6	Shwe Hlan Bo PIP	3,000	1,214	Dokhtawady River - Left bank	Sint Kiang	Kyauk Se	Mandalay
7	Sin Dat PIP	6,500	2,631	Ayeyarwaddy River-right bank	Sagaing	Sagaing	Sagaing

2. Existing Situation

Myanmar's economy is based on agriculture, oil, gas and hydroelectricity exports. It is growing rapidly based on a combination of the above and between 2004 and 2009 the agriculture sector grew 12%. Agriculture still dominates Myanmar’s economy with two thirds of its rural population either directly or indirectly engaged in the agricultural sector. Rice is by far the most important crop in the country (nearly 70% of the cultivated land) followed some way behind by pulses (10%). Other important crops are cash crops of beans, sunflower, chillies and vegetables.

Since the reforms of 1988, the government has pursued market-oriented economic policies. Although this required the selection of *Policy* and *Priority* crops, with support and incentives provided for their production, with the new government formed in 2011, the demands relating to these crops have been considerably relaxed. The choice of crops has now been left to the producers although in practice this has yet to reach field level and to be incorporated in Township plans. The private sector continues to be involved in supporting farmers with services such as crop protection, seeds, fertiliser and farm machinery. Access to reliable markets for agricultural products continues to be variable and is dominated by exports to the Chinese market. Other markets such as to India have proven to be very variable and this reflects on the choice of crops that the farmers grow. Other then the dominant crop of rice, farmers are aiming more for local markets.

Following Nargis, government has been pursuing food security at both national and household level as key objectives. Agricultural policies are export oriented, though taxes on agricultural imports and exports put Myanmar farmers at a regional disadvantage.

Since Myanmar’s independence in 1947, all land has been owned by the State. Farmers are given usufruct rights that cannot be transferred, mortgaged or used as loan collateral, but can be inherited by their family who must continue to cultivate it to retain possession. However, there is evidence of a vibrant market for sharing land and it has been estimated that about 20% of the reported 50% landless rural village households utilise land in this way[10]. This was confirmed by the site visits. Size of land holdings vary considerably and although are small on average, 0.8 to 2 ha[11], much larger landholdings were reported in some areas especially on the right bank of the Ayeyarwaddy where holdings were reported to be up to 10 ha.

The contents of this report will have utilised the information gained during the site visits and discussions with officials and farmers in each area. A summary of these field notes have been provided in Annex M to this report to assist WRUD in assessing the way forward for the seven pump irrigation projects (PIPs) visited.

2.1. Ministry of Agriculture and Irrigation

The Ministry of Agriculture and Irrigation (MOAI) is the main Ministry involved in water resources, with the mission to develop agriculture and irrigation in the country. It was renamed in 1996 in order to

[10] FAO. Personal communication.
[11] National statistics show that 80% of all holdings are 2 ha.

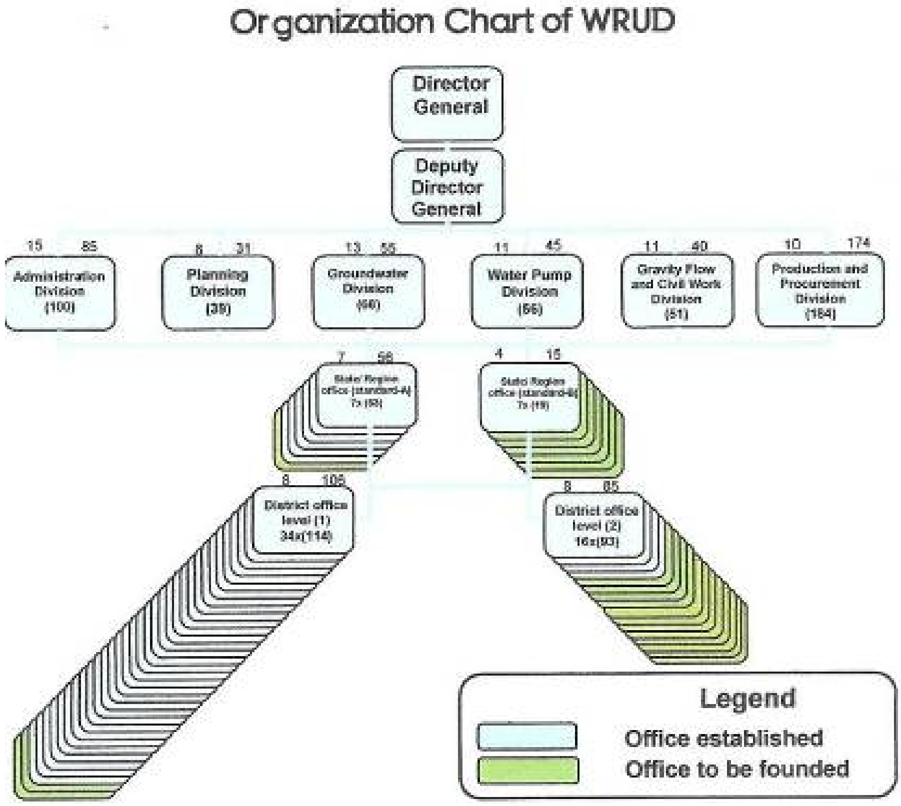
acknowledge the importance of irrigation in agriculture. Among several strategies identified by MOAI for meeting agriculture sector objectives are: (a) the provision of irrigation, (b) the application of modern agro-technologies including improved seed, (c) fertiliser and crop protection, (d) the development and utilisation of new crop varieties, and (e) the adoption of cropping patterns that fit the local agro-ecology. The 10 crops that are being promoted include: paddy, long staple cotton, groundnut, sunflower, the grams (yellow, green and black), sugarcane, pigeon pea, and maize.

The following departments of MOAI are involved in water resources:

- **Water Resources Utilization Department**: responsible for groundwater use (for both irrigation and rural water supply), irrigation by pumping in rivers, and the development of sprinkler and localized irrigation
- **Irrigation Department**: responsible for operation and maintenance of irrigation works, construction of new projects, and investigation, design and implementation of proposed projects, as long as surface water is used
- **Settlement and Land Records Department**: responsible for collecting agricultural statistics and land administration
- **Agricultural Planning Department**: in charge of planning, monitoring and evaluation of all agricultural projects, including irrigation and drainage projects

The Meteorology and Hydrology Department of the Ministry of Communication, Posts and Telegraphs is in charge of collecting hydrological and meteorological data, while the Irrigation Department also has its own hydrological network. Hydropower generation is supervised by the Myanmar Electric Power Enterprise, within the Ministry of Electric Power.

Figure 2. Water Resources Utilization Department



Source: WRUD

2.1.1. Myanmar Agriculture Service

The Myanmar Agriculture Service (MAS) coordinates farm advisory services and research and is an agency within MoAI. Its functions are carried out by the Managing Director, with eleven divisions (i)

Central Agricultural Research Institute, (ii) Seed Division, (iii) Land Use Division, (iv) Agricultural Education Division (AED), (v) Oil Crops Division, (vi) Pulses Division, (vii) Vegetable and Fruit Division, (viii) Plant Protection Division, (ix) Procurement and Distribution Division, (x) Project Planning and Management and Evaluation Division and (xi) Administration Division and Accounts Division. It employs a total staff countrywide of about 13,000 about 10% of whom are graduates. IED is responsible for the delivery of farm inputs including seeds and farm advisory services. State Economic Enterprises under MOAI such as the Myanmar Industrial Crop Development Enterprise that deals with cotton, have their own specialised crop advisers.

The field discussions with farmers revealed that the service provided by MAS is very variable. The performance depends very much on the individuals involved who are generally well trained in specific policy crops but who are not in most cases well equipped to advise on other cash crops. Frequency of visits depended on the area and varied from once or twice a week in certain cases down for a more general once or twice a month to once a year or less in the less accessible areas. Although AED and MAS research institutions are widely distributed and are strategically located in all agro-ecological regions of the country, staff are spread too thinly and suffer from severe budget constraints. The greatest effect of these constraints is felt at the lower field levels of farm advisory and research staff, who have limited field training materials and very low allowances for transport.

2.1.2. Agricultural extension institutions

The agricultural education institutions that are meant to underpin the AED with specialised crop advisers and research staff, have also seen inadequate budgets over a number of years and have failed to produce suitably qualified staff in the required numbers. There are seven State Agricultural Institutes with the Yezin Agricultural University (YAU) at the apex, plus several agricultural research institutes that also provide specialised training for farm advisers. In-service training is offered by the Central Agricultural Research Institute and its associated Development and Training Centre. The Agricultural Institute at Pyinmana offers general training for agricultural extension workers who have completed secondary school. Experienced extension and research staff exist in some institutions, but the supply of staff to fill their places is limited and they have not received sufficient training for the tasks to be undertaken. This has been exacerbated by insufficient exposure to international developments and progress in research activities.

2.1.3. Agricultural services delivered

The methodology of farm advisory services has been developed out of the command economy with the weaknesses that derive from this approach including top-down delivery with limited participatory contact with their target group, the farmers. Model farms and MAS demonstration sites are seen throughout the areas visited, but what is most noticeable is the lack of implementation of ideas onto the neighbouring farms. Discussions revealed that research and farm extension messages are focused largely on increased production of individual crops, with use of correct techniques and inputs that are often beyond the resources of the less well-off farmers. Advice on the full range of crops that are actually grown on land is lacking as well as the availability of many of the inputs including quality seeds and access to seasonal credit. Marketing and farm economics advice are largely absent from advisory messages. Most extension messages are conceived centrally and are passed down with limited adapted testing, feedback or adaptation. The approach of MAS would indicate that an appreciation of the modern techniques of communicating effectively with farmers is lacking.

It is widely recognised, not least by MoAI itself, that research and farm advisory services are unable to respond effectively to the current needs of farmers, and are certainly not equipped to support the type of farming systems that exist on many of the pumps irrigation project sites. Improvements in the approach and delivery of the services provided by MAS will take time but before this can be achieved, it has to be recognised that there are other ways of supporting the farmer and delivering appropriate services. Within MOAI alternative approaches are taking place, such as with MICDE and the support to cotton, but this has yet to be realised in the support to PIPs as the field visits have emphasised. On all sides, the greatest deficiency after water availability was the lack of adequate farm advisory and agricultural support services.

2.2. Climate and Soils of the Central Dry Zone

Myanmar's climate is tropical monsoonal. Rainfall is highly seasonal, being concentrated in the hot humid months of the southwest monsoon (May-October) and with significant regional variations associated with the intensity of the rains. Mean annual rainfall is estimated at 2,341 mm but in the central dry zone (CDZ), it declines to 500 - 1,000 mm (Figure 3). River flows are directly influenced by the main monsoon season and rise in June and decline from September onwards. The monthly distribution of river flows closely follows the pattern of rainfall, with about 80% occurring during the monsoon season (May-October) and 20% in the dry season (November-April).

Average rainfall patterns form the central and northern parts of the CDZ are illustrated in Tables 2 & 3. The pronounced dip in the middle of the rainy season around July is clearly illustrated. Although these monthly values of effective rainfall can still be considered reasonably valid, there are pronounced variations within the months and the start of the monsoon season can be very uncertain. In 2011 there was significant rainfall in April and this allowed the more experienced rainfed farmers, who considered this sufficient for an early crop, to plant sesame.

Table 2. Average Long-term Rainfall for Meiktila

	Rain mm	Eff rain mm
January	3.0	3.0
February	1.0	1.0
March	1.0	1.0
April	29.0	27.7
May	149.0	113.5
June	103.0	86.0
July	63.0	56.6
August	100.0	84.0
September	159.0	118.6
October	156.0	117.1
November	31.0	29.5
December	25.0	24.0
Total	820.0	661.9

Table 3. Average Long-term Rainfall for Mandalay

	Rain mm	Eff rain mm
January	3.0	3.0
February	48.0	44.3
March	6.0	5.9
April	49.0	45.2
May	129.0	102.4
June	120.0	97.0
July	94.0	79.9
August	116.0	94.5
September	164.0	121.0
October	86.0	74.2
November	34.0	32.2
December	9.0	8.9
Total	858.0	708.2

In the central dry zone, the Ayeyarwaddy-Chindwin River[12] basin provides a good source of irrigation water. It is however incised in its river course which means that access to gravity supplies have to be achieved either from its tributaries or through pumping from the main river course. Because of its wide variability in discharge over the year and the occurrence of sandstone within the catchment, sedimentation and river meandering predominate in middle, below the junction with the Chindwin River, and Lower Ayeyarwaddy. Because of the rainfall and hydrological pattern of the country, the need for irrigation is highest in the central dry zone, while the delta is more concerned with drainage and flood protection problems.

The dry zone represents an unusual part of Myanmar that is feeling the full effects of climate change. Variability in rainfall is not new to the area, but the extent to which the pattern of rainfall events is changing is having a dramatic impact on rainfed crop production. Monsoon rainfall occurrence shows pronounced periods with reduced or no rainfall during the monsoon season that in dry years has

[12] entirely located in Myanmar, drains 58% of the territory

impacted very negatively on rainfed production and thus on the livelihoods of people living within the area. Irrigation that is planned together with the farmer and implemented in a sustainable manner considering not only capital investments but running and operation and maintenance costs and farmers'resources as part of the complete picture can play a significant role in stabilising production in this area.

These soil sources and land suitability were examined in early 2003. Useful maps have been produced although the ones made available are not detailed enough for detailed project planning (Annex J) and do not identify the considerable variations that occur in the proximity of the outcrops of sandstone. They do however give a good indication of the soil texture and it can be seen that on the right bank of the Ayeyarwaddy near to Mandalay the soils are generally better than those around the southern border of the division with Magwe.

2.3. Irrigation in Myanmar

Myanmar has a long history of irrigation that extends back to the former kings. The functioning of irrigation in modern times extends back to when the irrigation Branch was established in the public works department in 1917. After independence in 1948, the irrigation branch continued maintenance of existing irrigation networks for agricultural development as well as embarking on new projects in various parts of the country. In 1972 the Irrigation Department was formed to o coordinate the development and management of water resources for irrigation.

Implementation of irrigation works had been given special emphasis especially in the central dry zone of the country. In addition to regular projects, there have been a number of "special" projects that have been given high priority. Further resources have been made available for these projects, but in many cases, the distribution systems that are being provided are not complete in that they do not extend down to field level. From 1993, following the intention to reach an annual growth rate for agriculture of 5.6%, the rate of increase of the number of projects was accelerated and this brought about what in retrospect was a period of insufficient detailed technical planning and design. By 2010, about 20% of its potential irrigated area of 10.5 million ha, was reported to be served by irrigation systems (Figure 4). About 10% of the equipped area is under pumped irrigation of which 70% is in the three central dry zone states of Magwe, Mandalay and Sagaing (Figure 5).

Table 4. Summary of irrigated areas in Myanmar

Irrigation potential		10 500 000	ha
Irrigation			
1. Full control irrigation: equipped area	2004	2 083 000	ha
- surface irrigation	2004	2 083 000	ha
- sprinkler irrigation	2000	0	ha
- localized irrigation	2000	0	ha
▪ % of area irrigated from surface water	2004	95.2	%
▪ % of area irrigated from groundwater	2004	4.8	%
▪ % of area irrigated from mixed surface water and groundwater		-	%
▪ % of area irrigated from mixed non-conventional sources of water		-	%
▪ area equipped for full control irrigation actually irrigated	2004	2 083 000	ha
- as % of full control area equipped	2004	100	%
2. Equipped lowlands (wetland, ivb, flood plains, mangroves)	2004	27 000	ha
3. Spate irrigation		-	ha
Total area equipped for irrigation (1+2+3)	2004	2 110 000	ha
▪ as % of cultivated area	2004	20	%
▪ % of total area equipped for irrigation actually irrigated	2004	100	%
▪ average increase per year over the last 9 years	1995-2004	3.45	%
▪ power irrigated area as % of total area equipped	1995	3.5	%
4. Non-equipped cultivated wetlands and inland valley bottoms		-	ha
5. Non-equipped flood recession cropping area		-	ha
Total water-managed area (1+2+3+4+5)	2004	2 110 000	ha
▪ as % of cultivated area	2004	20	%

Source: FAO Aquastat, 2010.

Figure 4. Rainfall distribution in Myanmar

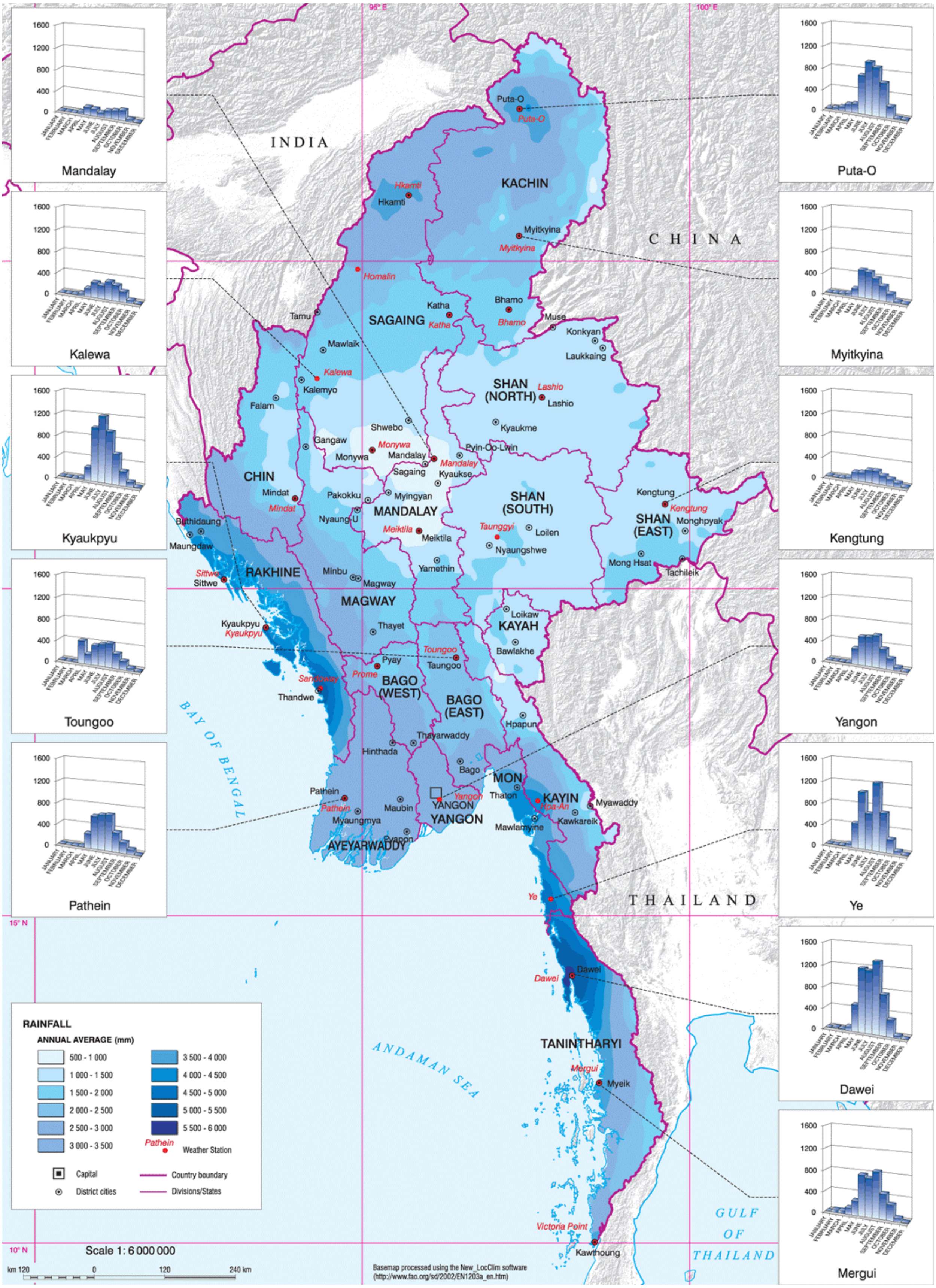


Figure 5. Distribution of Irrigation in Myanmar

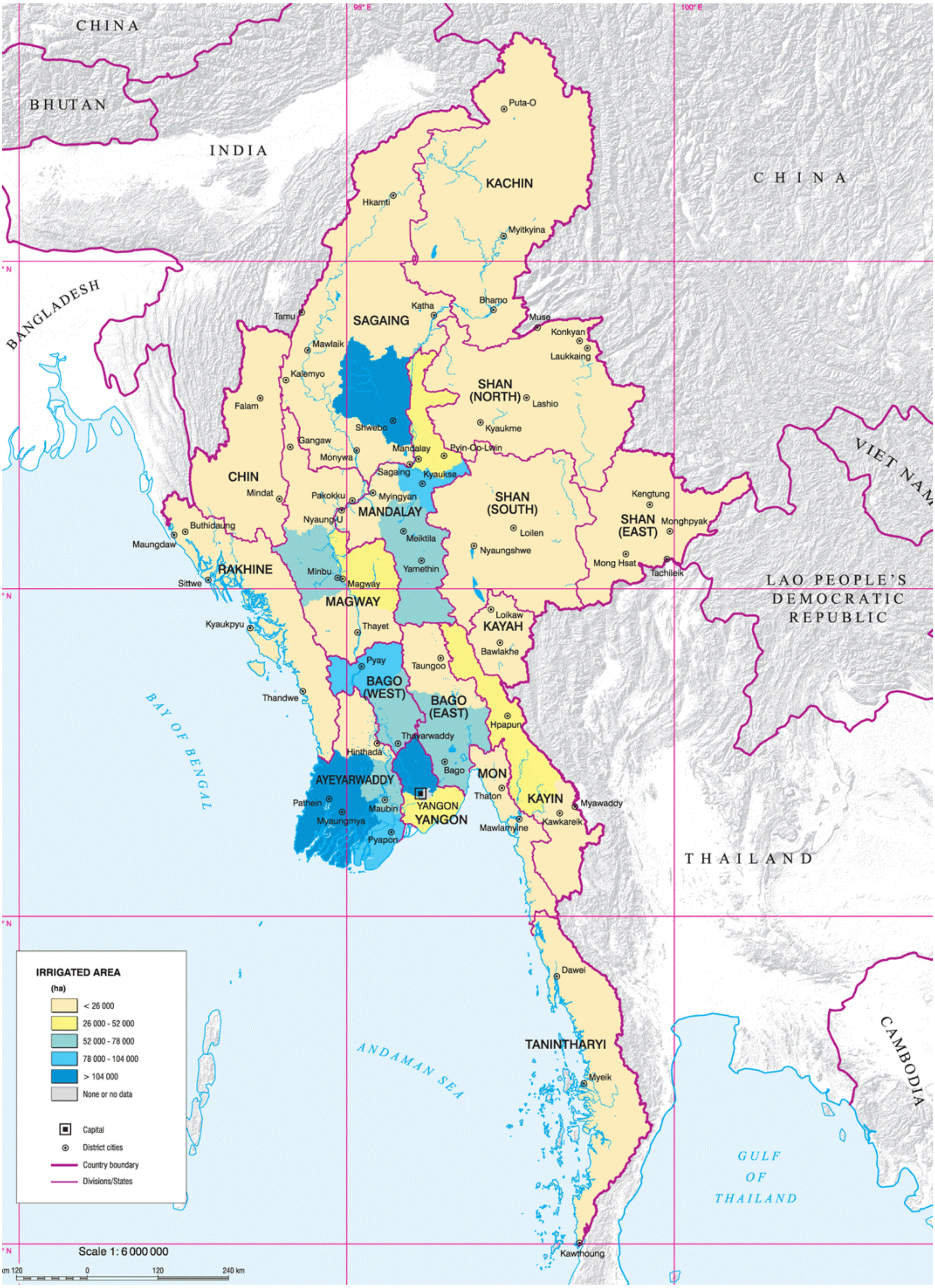
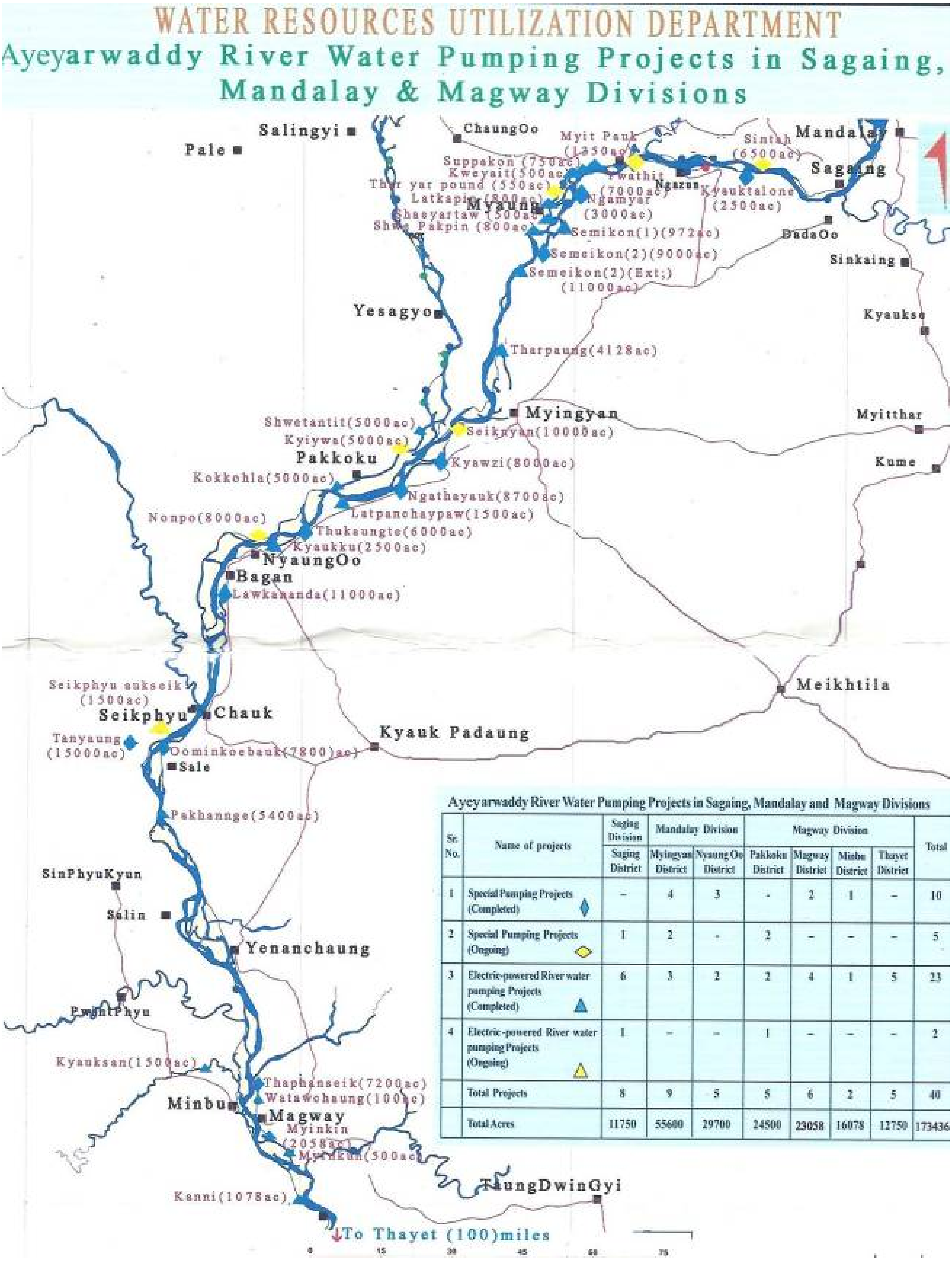


Figure 5. Location of PIP is in the Central Dry Zone



Ayeyarwaddy River Water Pumping Projects in Saging, Mandalay and Magway Divisions

Sr. No.	Name of projects	Saging Division	Mandalay Division		Magway Division				Total
		Saging District	Myingyan District	Nyaung Oo District	Pakkoku District	Magway District	Minbu District	Thayet District	
1	Special Pumping Projects (Completed)	–	4	3	-	2	1	–	10
2	Special Pumping Projects (Ongoing)	1	2	-	2	–	–	–	5
3	Electric-powered River water pumping Projects (Completed)	6	3	2	2	4	1	5	23
4	Electric-powered River water pumping Projects (Ongoing)	1	–	–	1	–	–	–	2
	Total Projects	8	9	5	5	6	2	5	40
	Total Acres	11750	55600	29700	24500	23058	16078	12750	173436

2.4. Main findings

The objective of the site visits was to view and discuss representative samples of the pumped irrigation projects that have been built or are being built in the central dry zone. The selection on these sites was carefully discussed with representatives from WRUD and as 70% of the interventions by WRUD are in the CDZ, it was considered that a good selection of these sites was visited. The detailed notes on the site visits (Annex M) have been drawn upon to arrive at overall conclusions and recommendations. The main issues arising are discussed further below.

2.4.1. Design Approaches

The design approaches seen on all seven of the pumped irrigation projects that were visited were similar and used more or less standard designs. Implementation had been construction driven and geared towards increasing the area under policy crops with the intention of increasing production. However, no feasibility studies were carried out as the designs had to be implemented very quickly from an engineering viewpoint and this resulted in little agricultural input into the design process. Decisions were made at a political rather than at a technical level where interventions derive from feasibility studies (with information on the current agricultural situation including soils) and follow-up designs. The assumption appears to have been that the soils were suitable for the identified chosen policy and priority crops and that the associated irrigation methods (predominantly basin irrigation) without confirming this through ground truthing. As the soils planned for irrigation included both Ayeyarwaddy floodplain and associated uplands, this was not the case and the result has been an overall efficiency[13] that is estimated to be much lower than anticipated with the area irrigated comprising 40 to 60% of the planned net command area (see section 3.3 below). The remaining areas that could not be irrigated within the command areas have been cultivated only in the monsoon season under rainfall conditions with relatively drought resistant rainfed crops of lower consumptive use. In some places second crops were possible through the use of residual moisture in the winter season but this occurred mainly on the alluvial soils close to the Ayeyarwaddy River course.

In many places, the on-farm network (tertiary canals and watercourses) had not been completed and this has been attributed to the poor response of the farmers. However, in many cases it would appear that little to no consideration had been given to how the on-farm network would connect with the primary network and what resources would be used to achieve this. The net result has been that in many situations more than 50% of the on-farm works remain to be completed with water passing from farm to farm rather than through a more formalised watercourse network. In addition to this, many of unlined canals have high seepage losses as they have been constructed from similar light soils that were not only unsuitable for paddy rice but too permeable for the construction of unlined canals. In these circumstances, it would have been normal to import clay lining material as a cheaper alternative to masonry lining. However, insufficient budget and design experience coupled with the political pressure to finish as soon as possible did not permit such considerations. The net result has been that water cannot reach the end of the canals and many farmers' fields remain unirrigated especially in the dry season.

Although rice grown under Paddy conditions is the most common crop in Myanmar, in the CDZ where areas away from the Ayeyarwaddy River course are derived from sandstone, oilseed crops, groundnuts and other cash crops more suited to the lighter soils are commonly found. Farmers in these areas who do not grow paddy rice are thus unfamiliar with irrigation relying solely on rainfed conditions. Furrow irrigation methods are more suited to these crops on more permeable soils and training would be needed for the farmers to show them how to irrigate efficiently. In addition to this, furrow irrigation is not common in many parts of Myanmar, and thus the design engineers would need to know how to prepare suitable designs.

[13] Conveyance, application and operational.

Net returns received by the farmers on pumped irrigation are around 10 to 20% less than those received by farmers for similar crops on gravity schemes. This is not only due to the cost of pumping, but also to the very low water charges on the gravity schemes (approximately 1/20th to 1/10th of pumped schemes). It is as important that both designers and operators are made aware of the need to consider that every unit of water that is delivered costs money. Efficiency in delivery of the water and the need to relate supply to demand should become of paramount importance. This is not reflected in practice.

All of the schemes have been badly affected by the variability of electrical power supply especially during the summer season. Regular outages occur and when this happens frequently during the day, it completely disrupts the scheme operation and efficiency of supply. Although recent hydropower developments have is the situation in the last 1 to 2 years, such problems will persist. Leakages from pipework and foot valves become significant in these cases and lead to a gradual draining of the water already pumped necessitating the refilling of the canal system before irrigation at the lower levels can be resumed.

Location of the pumping stations has been very important considering the meandering of the Ayeyarwaddy River. Although conditions will have changed since initial siting of the pump stations, in some cases, selection of the site for the pump station could have been much better.

In Shwe Hlan Bo project, attempts have been made to improve on the initial design and is approaches have already improved on its efficiency. Scheduling of water and measurement of water delivery at the different canal levels within the scheme still needs to be carried out together with greater involvement of the WUAs in operation and maintenance and the financing of the same.

As has been mentioned earlier, detailed consideration to agricultural, social and economic aspects of schema design was not carried out as no such staffs are employed by WRUD. As crops were chosen on the basis of national preferences and design norms had been established for these crops, it was not considered important at that time. In spite of this, farmers have reacted and adapted rationally, but still constrained by the lack of appropriate tertiary and watercourse systems and the need for land levelling.

2.4.2. Construction status

Construction of the PIPs concentrated on the pump stations and the main and distributary Canals. If the financial resources were provided in a timely manner, construction proceeded well. In most cases, this was not the case and thus construction has extended much longer than was really necessary. The quality of construction work has generally been good particularly as the design is utilised have been familiar with the site implementation staff. Where adverse soil conditions or topography were encountered, this presented problems not only in the completion of the projects within available budgets but also in ensuring sustainability and minimal annual maintenance. Table 5 provides information on the current construction status of each of the sites visited.

2.4.3. Design Capacity and Experience

Examination of the design processes has shown that many Engineers in WRUD do not have appropriate irrigation and drainage design experience. The institutions from which they graduated aimed at producing construction engineers (civil engineers) to implement designs that they have been provided with. Although they received some design training, this was not sufficient to enable them to adjust or modify designs on site during implementation. Thus, although construction has been of a good standard, in most cases where major design changes or improvements were required; these had to be referred back to the design group in the WRUD head office in Naypyidaw. This design group had few people who understood all were trained in irrigation and drainage design and even now their teams comprise civil, electrical, mechanical and geotechnical engineers with no agriculturalists, economists, sociologists or water management experts. Limited attention was therefore paid to the type of crops grown before initiation of PIP and farmers' experience with the soils and crops which is a good indication of potential future crops that could be grown on these soils.

Table 5. Details of Construction Status on Sites Visited

No.	Project Site (Pumped Irrigation Projects) (PIP)	Construction Years	Status of Construction	Development scenario
1	Law Ka Nandar PIP	2001 to 2004	Completed except for tertiary	Operational, but only about 50% used for pumped irrigation.
2	Lat Pan Che Baw PIP	1995 to 2001	Completed but lateral and watercourses not complete for PS-2	Operational with water shortages in Summer season
3	Hnone Poe PIP	2004 – 2011 +	Pump Stations not equipped and so no water is pumped. Main canal completed in 2007	No operational.
4	Kyaw Zi PIP		Completed but only about 50% of scheme is operational due to damage and lateral and watercourses not complete for PS-3	Operational but water shortages in both main seasons
5	Simeekone-3 PIP	2009 - 2013	Main canal at River to about 1+000, but much work remaining. No work yet done on Distributary and below canals or on the pump stations	Not operational.
6	Shwe Hlan Bo PIP	On Going	1st Stage completed, next stage due 2012	Operational, but some watercourses still need to be completed in Phase 1. 2nd Phase has main canal part completed with other canals remaining.
7	Sin Dat PIP	May 2004 – 2010 +	Meant to be completed. Design faults re soils. Few tertiary and Watercourses completed as well as a number of distributaries.	Serious conveyance & operational losses. Water supply in Summer season is very restricted.

Design of the canal structures has been based on proven designs that have worked well and whose construction is within the capacity of local masons and skilled labourers. Pump stations and canal conveyors (main canal; distributary canal;) have been designed on the basis of water duty to give the maximum design discharge from the canals. However, those operating the PIP and responsible for delivering the water to irrigation systems have insufficient experience with water scheduling and have no clear indication of the actual amounts of water that are being pumped into the systems. Without any measuring structures, the operators assume that the water pumped under a wide variety of head conditions (the variations in high water level to low water level in the Ayeyarwaddy River is 20 to 25 feet) conforms closely with the rated capacity of the pumps. This is unlikely to be the case in practice.

2.4.4. Existing Agriculture

Unlike the other irrigated projects within the country, the PIPs cannot grow a 100% rice crop in the monsoon season (Table 6). On the heavier soils and those soils verging towards the upland sandy soils, rice is grown in the monsoon season with oilseeds and pulses grown on the more permeable soils that have much less water holding capacity. Higher water tables in the monsoon season reduce the impact of these latter songs to some extent and facilitate the cultivation of rice. However, in the winter and summer season, this does not occur and us water losses are high on the soils and the area that can be irrigated is considerably reduced. Cropping intensities achieved thus vary from 83% up to about 133%. This is low compared to the relatively high investment and what should be achievable on such schemes.

Average yields of paddy are low and are principally constrained by lack of improved seed. Farmers are acutely aware of this but lack access to it. If improved seed is not delivered concurrently with the provision of irrigation and drainage facilities, then the benefits attributed to providing irrigation are considerably reduced. The problem and how to address it are discussed later with more details provided in Annex F, Improving Seed Production.

Another main constraint is farm advisory services that are largely ineffective. The reasons for this are discussed earlier and indicate that significant changes in approaches are needed. Improved direct involvement with the farmers, such as through farmers field schools, is essential together with significant improvements in training of extension staff and implementation of training for Lead Farmers (see Section 3.8.1). I

Table 6 Details from Project Sites Visited

No.	Project Site (Pumped Irrigation Projects (PIP))	Design Command area			Design Crops (ha)					Actual (Estimated) Ha.									Water Source	Design Discharge	
		Acres	Ha	CI%	Paddy	Cotton	Oil Crops	Other	TOTAL-All crops	Paddy	Cotton	Green Gram	Ground nut	Sesame	Maize	Other	TOTAL-All crops	CI%		Cusecs	l/s/ha
1	Law Ka Nandar PIP	**11000**	**4452**	**150%**	**40**	**607**		**3804**	**6677**									**100%**	Ayeyarwaddy	200	1.272
	Monsoon-Irrigated	11000	4452		40	607		3804	4452	522	17	1025	739	21		95	2419		River-left bank		
	Monsoon-Rainfed											436	1119	30	185	263	2033				
	Summer	5500	2226		40	607		1578	2226												
2	Lat Pan Che Baw PIP	**1500**	**607**	**150%**	**405**	**40**		**162**	**911**	**105**	**12**	**40**				**55**	**809**	**133%**	Ayeyarwaddy	33	1.555
	Monsoon	1500	607		405	40		162	607										River-left bank		
	Monsoon-Irrigated									311	3	35				157	506	**83%**			
	Monsoon-Rainfed									0				46		46	91	**15%**			
	Summer	750	304		304	0		0	304	105	12	40				55	**212**	**35%**			
3	Hnone Poe PIP[2]	**8000**	**3238**	**150%**	**405**	**809**	**1214**	**809**	**4856**										Ayeyarwaddy	200	1.749
	Monsoon	8000	3238		405	809	1214	809	3238										River-right		
	Monsoon-Irrigated									0	0	0	0	0	0	0	0		bank		
	Monsoon-Rainfed									0	275	826	550	550	0	550	**2752**	**85%**			
	Summer	4000	1619		405	809	0	405	1619	0	0	0	0	0	0	0	0				
4	Kyaw Zi PIP[1]	**8000**	**3238**	**150%**	**1619**	**405**		**0**	**4856**								**4856**	**150%**	Ayeyarwaddy	150	1.312
	Monsoon	8000	3238		1619	405		0	3238										River-left bank		
	Monsoon-Irrigated	4588	1857							1000				428		428	1857	**57%**			
	Monsoon-Rainfed	3412	1381							619				381		381	1381	**43%**			
	Summer	4000	1619		1619	0		0	1619				540	540		540	**1619**	**50%**			
5	Simeekone-3 PIP[2]	**15000**	**6070**	**150%**	**0**	**0**		**0**	**0**										Ayeyarwaddy	250	1.166
	Monsoon	15000	6070		0	0		0	0										River-left bank		
	Monsoon-Irrigated									0	0	0	0	0	0	0	0				
	Monsoon-Rainfed									0	516	1548	1032	1032	0	1032	**5160**	**85%**			
	Summer	7500	3035		0	0		0	0	0	0	0	0	0	0	0	0				
6	Shwe Hlan Bo PIP-Phase I[3]	**3500**	**1416**	**157%**	**809**	**405**		**0**	**1619**	**1533**	**40**	**50**	**30**	**0**	**0**	**383**	**2036**	**144%**	Doathtawady	100	1.999
	Monsoon	3500	1416		809	405		0	809	1133						283	**1416**	**100%**	river - Left		
	Summer	2000	809		405	0		0	809	400	40	50	30	0	0	100	**620**		bank		
7	Sin Dat PIP[4]	**6500**	**2631**		**0**	**0**		**0**	**5600**	**100**	**0**	**0**				**245**	**3075**	**117%**	Ayeyarwaddy	150	1.614
	Monsoon	6500	2631		0	0		0	2631										River-right		
	Monsoon-Irrigated	2200	890							800	0		0	0	40	50	**890**		bank		
	Monsoon-Rainfed	4300	1740									600	230		630	280	**1740**				
	Summer	1100	445		703	81		567	2970	100	0	0	0	100	0	245	**445**	**17%**			

Notes

1. 3412 Acres cannot be irrigated due to canal damage and water shortage.
2. Still under construction
3. Phase II under construction
4. Can only deliver water to about 1/3 of the area in Monsoon season due to high losses in systems

Farmers' knowledge of agriculture is generally good, but only with the narrow range of crops that they are experienced with. With the wider range of crops now being grown, farmers have expressed a clear need for more extension support especially for the wide range of other crops being grown. Even with the policy crops, the approach adopted has been instructional using demonstration and model farm areas that receive relatively higher investments that farmers find difficulty in relating to with their limited budgets. The poorer and less experienced farmers are thus slow or not adopting messages from MAS and model farm sites. However, where farmers are experienced in growing policy and other crops, where soils have been suitable and PIP have been developed from earlier smaller irrigation schemes built by the Irrigation Department, good crops are grown. Under these circumstances, the biggest problem facing farmers is the quality and availability of seeds especially for the less well-placed and poorer farmers.

2.4.5. Crop Water Requirements and Water Scheduling

Although there are details within the design manuals of WRUD and ID, no clear guidelines are available for design staff to determine crop water requirements (CWR) for existing or new projects. The staffs engaged on PIP design are civil engineers, the most senior of which have experience of irrigation. No staffs have formal irrigation training. In practice therefore, CWR are not determined on a weekly, ten-day or a monthly basis. The system design capacity for the main canal and pump stations have been determined considering the design water duty of the crops to be grown and this provides the maximum design requirement for the sizing of the pump stations and the canals. In practice only the water duty for rice is utilised (1 cusec/50 acres for 24-hour flow (1.4 l/s/ha) or 1 cusec/25 acres for 12-hour flow (2.8 l/s/ha). This is a reasonable assumption[14] provided that project efficiencies are correctly estimated. In practice the conveyance and application efficiencies are much lower than the overall project efficiency of 0.51 (see section 3.3 below).

Scheduling of water is not carried out in relation to meeting crop water demands that vary over the season depending on rainfall and evapotranspiration and different stages of plant growth. At all of the operational schemes visited and in discussions with field staff from WRUD, it was concluded that pump operators do their best to meet the needs of the farmers by pumping as long as is possible with the budgets available and when electricity supply is not interrupted. This in fact only secures water to those farms located on the less permeable soils and closer to the supply canals in both irrigation seasons. No reductions appear to be made for periods with reduced evapotranspiration or when the plants are at lower growth stages. This results in over irrigation at certain times of the year and is evidenced by accumulation of water in low-lying areas and drainage canals.

One of the problems experienced by WRUD is that the staffs that are running the schemes once they have been completely are derived from several engineering disciplines including mechanical engineers. Few have the necessary training or background to be able to make more informed decisions on when to cut back on flows in the canals mean the farmers agricultural needs. This situation is exacerbated by the considerable water loss experienced in the distributary and lower canals and the incomplete tertiary and watercourse canals in many of the command areas.

The engineering approaches have also been affected by construction budgets that are either untimely or inadequate or both. This has meant that implementation rates have been slower than expected, corners have had to be cut (such as reducing lengths of canal lined, etc) and this has impacted on sustainability and ability to deliver water in an efficient and timely manner.

2.4.6. Agricultural Water Management

The general level of agricultural water management is extremely low with water being wasted in many places. As has been shown on the gravity irrigation schemes built by ID, although farmers are well aware of the need for water, because of very low water charges that include no energy charges coupled with

[14] It results in about 800 mm delivered to the crop

the inadequate PIP designs, the water available is treated with a low value in the same way as on gravity supplied schemes. Costs of water delivered on the PIP are directly related to pumping energy and where water is not well utilised, the costs per unit of water increases significantly. This situation is exacerbated by the shortage of electrical energy especially in the summer season. Not only are the amounts of water supplied to the systems severely affected by this, on each occasion when power supply is resumed again, time is taken to refill part or the entire canal conveyance network to compensate for water that has drained away during the period with no power available. Even though the situation has improved over the last two years, there are still significant energy shortages in the dry season.

(a) Water Users Associations

On the operational irrigation schemes visited, water users associations existed. They are formed around the watercourse unit which is usually about 10 ha or 25 acres and comprise about 10 farmers. This is the model used by the Irrigation Department and WRUD has adopted the same. There is wide variation on landholdings within the schemes, but in the absence of detailed information, this provides the basic building block. On the schemes that are still under construction, formation of WUAs is not carried out until construction has been completed. The exception to this is on those existing irrigated areas whose command area has been increased through the provision of pumps. For extension areas to existing irrigation schemes, establishment of WUAs are treated in the same way as new projects and await the completion of the main system.

On the already established irrigation schemes, farmers are involved in discussions with the WRUD prior to the start of the irrigation season on the type of crops to be grown in each area. There are regular weekly meetings to discuss water delivery and other problems and on a monthly basis formal meetings are held. When water is short, priority is given to those areas that have heavier soils and that grow preferred government crops.

(b) Water Charges

Water charges for farmers are fixed throughout Myanmar. They vary between gravities bed schemes and pump schemes with the latter being 10 to 20 times greater. They PIP charges are based upon crops grown and the water duty of that crop (Table 7). These do not resemble the actual costs that are incurred by government in support of these irrigation projects and have been determined by government to encourage farmer's activities in selected crops. It is recognised that they do not cover operation and maintenance costs and as the funds received by WRUD, who are responsible for the collection charges on each site, are not used directly for O & M but returned to central government, there is no direct link between the two[15].

Table 7. Details of Water charges on PIPs

Crop	Season		Crop water requirement (acre-feet)	
	Monsoon	Summer	Monsoon	Summer
Paddy	6000	9000	4	6
Other crops	4500	4500	3	3
Groundnut	4500	4500	3	3

Notes:

1 Based on recommended quantity of water in acre-feet
2 Rate assumed in Kyat per acre-feet = 1500

As government contributions to maintenance are very inadequate, only limited maintenance is carried out on the PIPs with the local project staff managing to the best of their ability to deal with the most urgent problems. At the tertiary and watercourse level, some cleaning is carried out by farmers to keep

[15] the funds received by the PIP for maintenance amount to a class a $1.5/ha which is about 1/20th of what would normally be required for annual maintenance.

water moving, but this is more reactive maintenance rather than planned regular maintenance. In some places, farmers are organised to contribute towards funding annual maintenance[16] although it is not clear whether this is widespread nor how the levels of contribution are determined.

2.4.7. Crop Budgets

During the site visits, data were collected to prepare crop budgets that reflect to some extent the current situation on each scheme. These have been included in the field notes in Annex M. When these are compared with the planned cropping patterns that were included in the original designs, large differences are noticed (Table 8). As mentioned earlier, the emphasis has been on government priority crops of paddy rice, cotton and oilseeds. Farmers and project staff had done their best to adapt the designs to the situation in practice.

Table 8. Planned Cropping on the PIPs Compared to Actual (monsoon season)

PIP	Planned Cropping, ha					
	Total command	**Paddy**	**Cotton**	**Oil seeds**	**Other**	**Total crops**
Law Ka Nandar	4,452	80	1,214		5,382	6,677
Lat Pan Che Baw	607	709	40		162	911
Hnone Poe	3,238	810	1,618	1,214	1,214	4,856
Kyaw Zi	3238	3,238	405			4,856
Simeekone-3	6,070					
Shwe Hlan Bo -Phase I	1,214	1,214	405			1,619
Sin Dat	2,631	703	81		567	4,589
	Total	**6754**	**3763**	**1,214**	**7,325**	
PIP	**Actual Cropping, ha**					
	Total command	**Paddy**	**Cotton**	**Oil seeds**	**Other**	**Total crops**
Law Ka Nandar	4,452	522	17	51	3,862	4,452
Lat Pan Che Baw	607	416	15	46	333	809
Hnone Poe	3,238		275	550	1,926	2,752
Kyaw Zi	3,238	1,619		1,349	1,100	4,856
Simeekone-3	6,070		516	1,032	3,612	5,160
Shwe Hlan Bo -Phase I	1,214	1,533	40		463	2,036
Sin Dat	2,631	900		100	2,075	3,075
	Total	**4,990**	**863**	**3,128**	**13,371**	

Because the fewer of the soils on the PIP have been suitable for paddy, the table shows that there has been a 26% reduction in the planned area for paddy. Although cotton is viable crop, only about a quarter of planned area has been grown mainly due to the current high financial risk to farmers (Annex E). Oilseeds are well above plan but this is largely attributed to sesame that is a drought tolerant crop with which the farmers are very familiar. This is grown in areas that are not irrigated. The greatest increase has been with the other crops with the area grown almost double that planned. These crops tend to be either profitable cash crops (Annex L) or those that are drought resistant such as gram that survives on poor soils. This is discussed further in sections 3.4 and 3.5.

2.4.8. Operation and Maintenance

Budgets allocated by Central government for the O&M of pumped irrigation projects have been very small and concentrated on meeting the energy charges with very small amounts allocated for other routine or non-routine maintenance work. At design, limited attention was paid to the management, operation and maintenance (MOM) of the PIP with no measuring structures included, no scheduling of water supplies and minimal actual involvement in the decision-making by the farmers. This has resulted in very small budget allocations[17] following construction and the systematic "mining" of the assets which have deteriorated further over time. The combination of inadequate annual budgets for O and M

[16] in Shwe Hlan Bo PIP, farmers were reported to pay Ks 10,000/acre for canal maintenance to be carried out by local contractor.
[17] On schemes such as these, only budgets in the order of $25-$50 per hectare would be the norm.

reduces the amount of water that can be delivered to the farms, how far the water goes and who benefits. Although cropping patterns are discussed regularly by WRUD with the farmers, without good maintenance and flow measurement, it is very difficult to match water supply to demand.

2.4.9. Development Costs and Budgets

Investment costs for the schemes visited were collected although this was complicated by the division of the costs into local currency and United States dollars. Past practice has been to use different rates for conversion of costs into US dollars and varied from 6 to 1000. However, for this analysis, the market rate has been assumed which were about Ks 1000 = 1 US$ at the time these cost estimates were prepared. This is now reduced to about Ks 750 = 1 US$.

When the development cost per hectare are reviewed, 6 of the PIPs have costs less send US$ 5,000/ha which would be considered as an appropriate cut-off rate for viable projects. However, such rules of thumb consider all development costs included whereas in many these schemes, tertiary and on-farm costs have not been included. Two of the PIPs would therefore be considered marginal investments (Simeekone-3 PIP & Shwe Hlan Bo PIP) and this is reflected in the financial analyses (Annex L).

Table 9. Summary Investments of Project Sites Visited

No.	Project Site (Pumped Irrigation Projects) (PIP)	Design Command area		Costs (Kyats - Million)				Costs (Kyats from US$ - Million)				TOTAL	Cost[18] (US$/ha)
		Acres	Ha	Civil Works	Elect-rical	Mech-anical	Sub Total	Civil Works	Elect-rical	Mech-anical	Sub Total		
1	Law Ka Nandar PIP	11,000	4,452	977	1,826	413	3,216	0	46	1,730	1,776	4,992	1,121
2	Lat Pan Che Baw PIP	1,500	607				0				0	0	0
3	Hnone Poe PIP	8,000	3,238	1,969	953	616	3,539	0	1,030	2,450	3,480	7,019	2,168
4	Kyaw Zi PIP	8,000	3,238				0				0	0	0
5	Simeekone-3 PIP	15,000	6,070	41,263	1,541	1,895	44,699	0	1,540	7,710	9,250	53,949	8,887
6	Shwe Hlan Bo PIP	3,500	1,416	4,376	1,373		5,749	18	820		838	6,587	4,651
7	Sin Dat PIP	6,500	2,631	2,402	361	282	3,045		1,091	233	1,324	4,369	1,661

Notes:
(shaded) = Cost Data not Available as built on old scheme

The viability of investments has also been significantly affected by the considerable delays in achieving benefits. Benefits have not come on-stream until the scheme is completely finished and even when this happens, for benefits are not achieved as much of the tertiary and watercourse systems still remain to be completed. Benefits delayed by only a few years affect the benefit/cost ratio effect and if this extends beyond 10 years results in negative ratios. At Hnone Poe for example, pump stations are not equipped so no water is pumped, though the main canal was completed in 2007.

3. Scope for Possible Intervention

3.1. Aim of Proposals

The field assessment has shown that a range of possibilities exist for jointly[19] supporting interventions to improve food production and food security in the central dry zone of Myanmar. These are presented in Table 4.1 with the details of improvements that can be achieved both in the short term (0 - 5 years) and in the longer term (>5 years). The overall intention of this assessment has been to provide a basis from which WRUD can initiate the review and upgrading of these PIPs to increase the net income for the farmers as well as raising production from the PIPs and thereby contributing to improved food security and a raising of the livelihoods of the people in the villages dependent on the schemes.

[18] In 1999, FAO estimated that average irrigation development costs varied from US$2,000-8,000/ha (12,300-49,100 kyatts/ha).
[19] Donor and Government of Myanmar.

3.2. Scope for Improvement

On most of the schemes visited, considerable potential for improvement exists in the short term. With more attention being paid to the appropriate delivery of water to the farmer, through engineering improvements, improved water delivery, agricultural support to the farmer and the more direct involvement of the farmers through the strengthening of water users associations. Through the greater involvement of the farmer in decision-making, significant increases in returns can be realised for all crops on all soils in both seasons. However, this will only be achieved through the better selection of the crops to be grown in relation to soil types and market demands and the improvement of extension support[20] and seasonal credit to farmers[21] to enable them to provide the correct inputs in a timely manner. Basin irrigation should only be used on the heavier crops where paddy rice can be grown easily. In other places where the lighter soils have a higher infiltration rate, other crops will be grown and furrow irrigation is required (see section 3.6).

The overall aim must be to get more crops per drop of water with water pumping rate related to crop water demand. Operational losses and energy costs/need per ha will thus be reduced. Although through this approach benefits will be achieved in the monsoon season, the greatest benefits will accrue in the summer season when many farmers within the command areas of the Pumped Irrigation Projects are currently unable to access irrigation[22]. This will raise the overall average cropping intensity from less than 100%, to around 160%. If this is achieved, which is feasible in a relatively short time frame, production for average to poorer farmers will be raised and have significant benefits in food security and livelihoods.

WRUD should therefore continue its proactive approach and adopt a more comprehensive rehabilitation and upgrading process for the existing PIPs, thereby taking advantage of complementing already sunk costs. A multi-criterion analysis is a useful device for developing a set of criteria and their importance weights is a 'value tree', which describes a hierarchy of objectives grouped at two or more levels.[23] Figure 6 below shows an example of a value tree that might be used for guiding decisions about the irrigation projects that compete for limited funds. This one has three levels, though in practice a criterion can be subdivided at a fourth level. The ten third-level criteria are grouped into four groups at the second level, which makes the model easier to develop. If this is used for the priority selection of the projects to be improved, it will ensure that those with the greatest potential are improved first. These will then serve as examples and training grounds for the staff of other projects.

3.3. Design Improvements

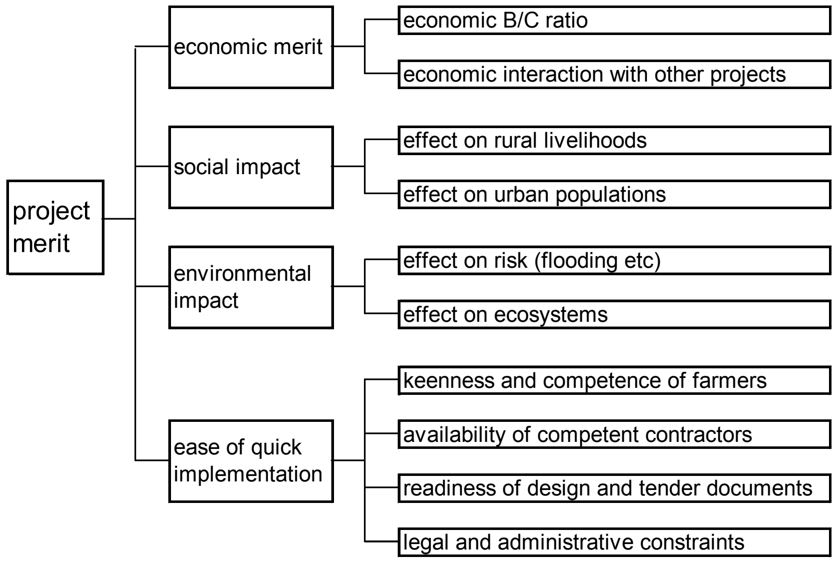
Considerable multidisciplinary and experienced technical assistance support to WRUD will be needed to improve planning and design approaches. Such support to WRUD necessitates the creation within the organisation of a multidisciplinary design and follow-up unit that is better equipped to meet the challenges especially relating to agriculture, farmer involvement and agricultural economics. Improved technical approaches and more detailed design will be introduced through a series of training sessions linked to an improved technical design manual. At the field level, implementation will be improved through targeted practical training for farmers, water users associations, site staff linked with more formal technical training of high-level professionals (section 3.9).

The basic building block for this approach is the production of a more comprehensive and complete Technical Design Manual. This will add to the good initiatives already started but will include current experience and knowledge on the agricultural, water management, operational, financial and social aspects of irrigation design. It is hoped that through this process, proper irrigation and drainage

[20] Improvement in effectiveness of extension services and adoption by farmers of improved practices through Farmer Field Schools (FFS) and lead farmers. These approaches are well proven regionally.
[21] Link with seasonal credit programs to assist farmers with credit to improve production
[22] The Consultants estimate that a maximum of only 40% of design flow is currently reaching users in the summer season.
[23] Belton & Stewart 2002, pages 66, 80-81, and 139-141.

engineers will emerge who have a full understanding of every aspect of irrigation systems. Given below are some of the issues that will need to be addressed.

Figure 6. Example of Multi-Criterion Value Tree



(a) Water delivery and availability

Indications from the field are that serious water shortages occur on all PIPs, particularly at times of peak demand in the summer months. These can result from several factors:

a) Design modules need to be based on balanced and phased cropping patterns with staggered planting dates avoiding high peak demands that the system cannot accommodate. In practice farmers are cultivating crops that they have been advised to grow irrespective of water requirements and systems capacity. The impact of this could be reduced if a flexibility factor was introduced into designs to allow for some degree of change in cropping pattern by farmers. This is in addition to other recommendations given below.

b) Diversion design modules are determined considering average peak water demands and continuous 16 – 20 hour flow. This has fixed the capacity in the main canal but results in over irrigation in the wetter months, using valuable funds for pumping often limiting supplies to the entire scheme. Existing projects need to be re-examined to reflect actual needs for irrigation over the seasons and scheduling supplies more closely to demands (see Annex D).

c) Water deliveries to farms are based on cropping patterns determined at the start of the season. There is limited flexibility in the way this water is delivered with supply deriving from these pre determined schedules and not adjusted within the season to accommodate changing circumstances (climate; water availability; actual cropped area and demands.).

d) Crop water requirements are not estimated with supplies related to maximum canal capacity rather than supply schedules[24]. Cropwat (Annex D) not only provides a more accurate estimate, more importantly, it permits scheduling of water deliveries to take account of different soil moisture holding capacities and filling regimes.

e) Canal capacities are determined using a Manning roughness coefficient of 0.015 based on as-built situations rather than the as-used conditions. An increase in this coefficient to 0.018 or even 0.020 would be more appropriate, particularly considering the quality of plastered brick

[24] The designers have limited opportunity and exposure to follow new techniques. They were unaware of the developments made with FAO's Cropwat program and that the software was freely available on the internet.

lining viewed during the field visits. For unlined canals, a roughness value of 0.027 would reflect better they used condition of the canals. (It should be noted that the combination of these two factors would indicate an under design of at least 10%).

f) Project efficiencies are derived from standard values (Table 10). These are unrealistic in practical situations and give rather generous values that will not be realized. An important part of the system efficiency is operation efficiencies. For open canal and multi stage pump schemes, there will be significant operational losses whilst gates are open, closed and adjusted, and whilst canals fill up with water. This will result from a lack of synchronization between gates closed by operators in one part of a system and gates opened in others to deliver water to different sections of the scheme. A minimum loss of 10% will result from this. In addition, designs should be made for average operational conditions that will exist in the system and not those that occur when the system has just been built. This will take account of the level of maintenance that actually takes place and for the lined canals, this has to acknowledge that construction joints are not repaired with asphaltic material which in practice leads to leaks from many joints. The box below indicates that using the WRUD data, an overall system efficiency of 50 percent results.

Table 10. WRUD Design Efficiency Assumptions (Source WRUD Design Criteria)

Type of Efficiency	WRUD Design	Estimated Actual
Field application efficiency Ea (other crops to Rice)	0.65 – 0.75	0.55
Field canal efficiency (Eb) Earth Channels (not normally considered separately and included by WRUD in Ec)	0.8	0.75
Conveyance efficiency (Ec) – Main & Distributary	0.8 – 0.9	0.75
Operation efficiencies (Eo)	0.85	0.75
Overall irrigation efficiency (Ep)	0.51	0.23

(b) Efficiencies

Surface irrigation schemes are designed and operated to satisfy the irrigation water requirements of each field while controlling deep percolation, runoff, evaporation and operational losses. The performance of the system is determined by the efficiency with which water is conveyed to the scheme from the headworks, distributed within the scheme and applied to the field, and by the adequacy and uniformity of application in each field. The different types of efficiencies in an irrigation scheme:

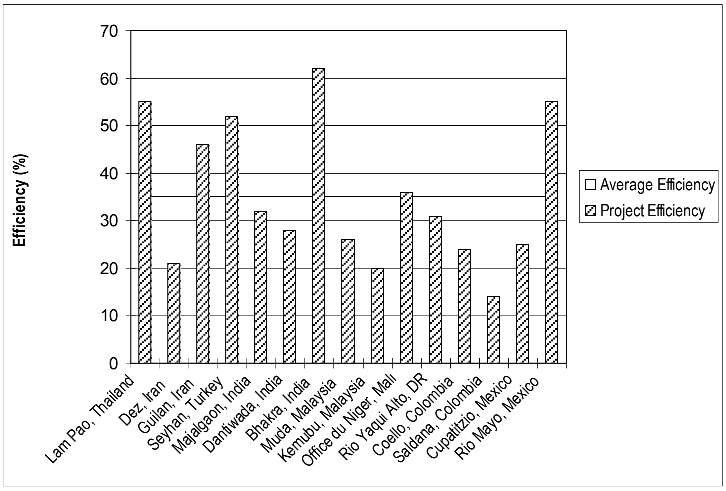
The overall efficiency, also known as project efficiency (Ep), comprises conveyance efficiency (Ec), field canal efficiency (Eb) and field application efficiency (Ea). According to FAO (1992):

- Field application efficiency (Ea) is the ratio between water directly available to the crop and that received at the field inlet. It is affected, for example, by the rate of supply, infiltration rate of soil, storage capacity of the root zone, land levelling, etc. For furrow and border strip irrigation, water is mostly lost through deep percolation at the head end and through runoff at the tail end, while for basin irrigation it is mostly through deep percolation and evaporation, since the basin is closed.
- Field canal efficiency (Eb) is the ratio between water received at the field inlet and that received at the inlet of the block of fields. Among other factors, this efficiency is affected by the types of lining in respect to seepage losses, by the length of canals and by water management. Piped systems have higher field canal efficiencies than do open canal systems.
- Conveyance efficiency (Ec) is the ratio of the water received at the inlet of a block of fields to the water released at the headworks (diversion weir; pump station; outlet from a dam). Factors affecting this efficiency include canal lining, evaporation of water from the canal, technical and managerial facilities of water control, etc. Conveyance efficiency is higher when water is conveyed in a closed conduit than when it is conveyed in an open one, since water in the latter is very much exposed to evaporation as well as to 'poaching' by people and to livestock watering.

- Distribution system efficiency (Ed) Conveyance efficiency Ec and field canal efficiency Eb are sometimes combined and called distribution efficiency Ed, expressed as: Ed = Ec x Eb.
- Project efficiency (Ep) is the ratio between water made directly available to the crop and that released from the headwork, or Ep = Ec x Eb x Ea.

An examination of overall project efficiencies carried out in 2003 by the Food and Agriculture Organization of the United Nations (FAO) found that very few systems in the world achieved overall efficiencies in excess of 50 percent. Averages for most countries varied from 25-40 percent with some few individual projects achieving much higher values, as shown in the following figure[25].

Figure 11. Individual Project Efficiencies for Different Parts of the World (FAO, 2003)



3.4. Changing Cropping Patterns

The field assessments and subsequent analyses have shown that the initial significant scope for improvement is in the selection of crops and cropping patterns and input improvements that will have an immediate effect on the yields. Opportunities exist for changing crops towards those with higher margins that could not be grown before irrigation was provided. The area under crops such as sesame and green gram will decline while summer paddy, higher margin pulses, oilseeds, and in the long term, cotton, will increase. There is also opportunity to change the pattern of crops and increase cropping intensity, especially in the winter and summer season, to make better use of available water and to increase crop margins. Monsoon paddy is growing to generally meet household needs and food security. Although it is generally lower yielding than the summer varieties, it has an important role in the farming systems and is expected to continue in about the same proportions. Higher yielding and more profitable summer paddy will be grown as a cash crop along with a range of other crops better adapted to the irrigation methods and soil conditions. Farmers are ready for such changes and new crops and changes in cropping patterns are likely to happen as soon as improved irrigation is delivered.

Crop yields are below what should be achieved under these conditions. This reflects the farmer's unwillingness to invest in inputs when they consider that irrigation water supply is unreliable. When this risk has been reduced through the improvements in proposed in this report, inputs can be increased through the provision and increased availability of improved seeds and crop inputs like fertiliser and crop protection. Many farmers are cash starved and rely upon credit to provide the required inputs at the correct levels. Currently this is not limited and mainly restricted to the priority crops. By linking the farmers to ongoing programs that provide access to seasonal credit, the average and poorer farmers will be able to take advantage of the above. Any interventions should therefore be run in parallel with improvements taking place in water delivery. Farm advisory services (FAS) are an essential element in this process and the proposals to improve FAS should initially start with the pumped irrigation projects.

[25] Irrigation and Drainage Performance Assessment, Practical Guidelines, Bos, Burton and Molden, CABI Publishing 2005.

The aim of the proposals is to:

- make recommendations for an improved match between crops and irrigated soil types;
- demonstrate and compare the profitability of different crops on different soils so as to facilitate future planning that incorporates a greater understanding by planners of farmers' cropping patterns;
- provide information that will facilitate decisions on irrigation rehabilitation and upgrading
- identify other inputs needed, such as improved seed and farm advisory services, to complement investment in infrastructural works.

3.5. Improved Crop Budgets and Returns to Family Labour

To illustrate the possible changes in cropping pattern and the benefits that can be achieved, gross margins were prepared for three PIPs, (Law Ka Nandar PIP; Lat Pan Che Baw PIP; Shwe Hlan Bo PIP). Three situations were chosen, the estimated existing situation (deriving from data provided by site staff and farmers), the short-term future situation (0-5 years) and the longer term future situation (> 5 years). As the PIPs contained both irrigated and rainfed areas both these options were included and as there were heavier soils suitable for rice cultivation and lighter soils that were more suited to other crops, this option was also included. Crop yields and prices were based on information collected during the field surveys but adapted so that they were more representative of an average farmer. The results are shown in the tables in Annex L.

The financial analyses (B/C ratio; IRR) have been carried out assuming a 12% discount rate and a period of 20 years. These have only been done to illustrate the impact of the changes that are proposed. For example for Law Ka Nandar, has B/C ratio of 1.02 under the existing situation, 1.73 in the improved short-term and 1.91 under the improved longer-term. The impact of delayed benefits and long construction period are also illustrated for this project and show that the B/C ratio drops to 0.65 in this scenario. This scenario is reflected in the other two analyses but in the case of Shwe Hlan Bo, the initial high capital investment is impacting negatively on the current situation and although this is a good project, is giving a benefit cost ratio of just about one.

Much of the data on which is analysis have been presented have had to be estimated as field data were not complete and there were inconsistencies. However, the analysis shows that by more appropriate selection of crops that are better suited to the soils and by improving the availability of irrigation water to the existing irrigated area, significant benefits can be achieved.

A number of factors impact on existing cropping patterns:

(a) The pressure from MoAI/MAS for farmers to grow the "policy" crops: paddy and cotton.
(b) Household food security. Farmers grow more traditional varieties in the monsoon season as these are preferred and regarded as less risky than the high yielding varieties. Irrigation water is unreliable, even in the monsoon season, and thus traditional varieties that are more drought tolerant are preferred.
(c) The balance between risk and profitability. Risk is more important in farmers' minds than margin or profitability, particularly with the effects of climate change and unreliable water supply. Improved availability of irrigation water will directly impact on risk and facilitate changing cropping patterns.
(d) Extension. The need for this was identified mainly by farmers during interviews. They need advice on markets, whole farm management, agronomy, fertiliser use, crop protection and many other subjects. Improved farm advisory services will have a substantial effect on changing cropping patterns.

The analysis also shows that with the current yields, the returns to labour for monsoon and summer paddy rice are low. Groundnut, high-value horticulture (HVH), sunflower and summer paddy become the interesting crops in the future. They do however illustrate that farmers are acting rationally in choosing crops with the highest returns to family labour within the boundaries of constraints and risks now presented by unreliable irrigation, unsuitable soils and climate change. They also illustrate how farmers are likely to react to improved irrigation, improved farm advisory services, a more sensible match of soils to crops, and better seed and other inputs. The following should be noted:

- Monsoon paddy is low risk but also low margin compared to the more profitable summer paddy, so the conclusion is that monsoon paddy will decline and make way for higher margin monsoon crops such as groundnut, while summer paddy will increase if irrigation is improved. Better seed will further improve crop budgets and yields for paddy.
- Cotton is too high risk and will not increase until in the long term better varieties are put in place or the present financial disincentives are removed
- Green gram has very low margins compared to the other pulses and oilseeds and will be replaced as soon as irrigation is improved. At present it will survive harsh conditions, so farmers grow it as a catch crop.
- Sesame has only a moderate margin but is drought resistant and is thus grown where irrigation is unreliable. Other more profitable oilseeds (such as sunflower) and pulses (such as pigeon pea and yellow gram) are likely to be grown instead of Sesame when the reliability of irrigation water improves.
- High value horticulture, including onions, chilli and sweet corn, has high returns to family labour but is also high risk. Irrigation water and other inputs need to be brought onto a much more reliable basis before farmers are tempted to increase its area. It is predicted to increase slowly.

The main reason for analysing returns to family labour in the crop budgets is to see how they relate to the local daily casual wage rate. This is a critical part of the farm analysis, and the same questions were asked about the same crops in all seven PIPs. Such interviews also included information on family size and the amount of family labour days available, the amount of hired labour used for each operation for each crop and how many days the farmers worked on other farms.

Crops that had returns to family labour close to the local wage rate, e.g. green gram, were corroborated by the farmers who confirmed that they were grown as opportunistic crops because of unreliable or no irrigation, or poor soil, or some other agronomic factor. In many cases alternative employment on neighbouring farms or elsewhere may often not be available and that is why green gram is a fairly widely grown crop throughout the PIPs.

Crops that had returns to family labour well above the local wage rate (which is most of them), sometimes almost six times the wage rate, are not necessarily an indication that a farmer is relatively prosperous. The returns per labour day may be high but there may not be many of them, and if he has a small farm, say 0.5 ha, he may have to spend half the year working off the farm, even though he is competing with landless labourers (reportedly 20% of rural families in the CDZ). However, it is an indication of the pressure to increase cropping intensity when the availability of irrigation water is made more widely available and for all three cropping seasons. As the crop budgets show that in general the returns to family labour are higher for the summer and winter crops than for the monsoon crops, these input would not conflict with cultivation of own land. This has formed the basis for the assumptions on increased cropping intensity in the short term – it will be a relatively rapid process – and for further increased cropping intensity in the longer term.

3.6. Irrigation Methods

Experience of irrigation in Myanmar has been dominated by the production of rice. Although a number of other crops are grown under irrigation, recent designers and users of the irrigation schemes have been familiar only with basin irrigation used for the growing of paddy rice. Furrow irrigation is not as well-known by both the farmers and the designers. With increased impact of climate change, especially in the central dry zone, and the need to look at much greater water management, there is a need for both designers and farmers to be familiar with other irrigation methods.

Furrow irrigation is the most widely used method for row crops and is the most misunderstood of all the surface methods. It is usually practiced on gently sloping land up to 2% in arid climates but restricted to 0.3% in humid areas because of the risk of erosion during intensive rainfall. This refers to downslope gradients and were steeper gradients exist, furrows can be constructed more cross slope. From a farming point of view, furrows should be as long as possible as this reduces the cost of irrigation and drainage and makes it easier to mechanise. The technique is well suited to larger farms and should not be confused with furrowed-basins which are best suited to small farms. Furrow length depends on soil type, steam size, irrigation depth and land slope and ranges from 60m to 300m or more but farm (or field) size and shape put practical limits on furrow length. Efficient furrow irrigation always involves runoff and so a surface drainage system will be needed.

Figure 12. Practical Furrow Lengths (FAO, 1988)

Practical values of maximum furrow lengths in metres depending on soil type, slope, stream size and irrigation depth for small-scale irrigation (Source: FAO, 1988)

	Soil type	Clay		Loam		Sand	
		Net irrigation requirements (mm)					
Furrow slope %	Maximum stream size per furrow (l/sec)	50	75	50	75	50	75
0.0	3.0	100	150	60	90	30	45
0.1	3.0	120	170	90	125	45	60
0.2	2.5	130	180	110	150	60	95
0.3	2.0	150	200	130	170	75	110
0.5	1.2	150	200	130	170	75	110

A furrow irrigation system consists of furrows and ridges, of which the shape, spacing and length depend mainly on the crops to be grown and the types of soils. Siphons are mostly used to take water from the field ditch to the furrows. According to Kay (1986), the width of the furrows varies from 250-400 mm, the depth from 150-300 mm and the spacing between the furrows from 0.75-1.0 m, depending on soil type, crops and stream size to be applied to the furrow. Coarse soils require closely-spaced furrows in order to achieve lateral water flow in the root zone. There is more lateral water flow in clay than in sand. Typical furrow lengths vary from about 60 m on coarse textured soils to 500 m on fine textured soils, depending on the land slope, stream size and irrigation depth. The minimum and maximum slopes for furrows should be 0.05% and 2% respectively in areas of low rainfall intensity. Most field crops, except very closely spaced crops such as wheat, as well as orchards and vineyards can be irrigated using furrows. However, with this type of irrigation there is a risk of localized salinization in the ridges.

(e) Efficiencies of the different surface irrigation methods

Furrow irrigation could reach a field application efficiency of 65% when it is properly designed, constructed and managed. The value ranges from 50-70%. Losses will occur through deep percolation at the top end of the field and runoff at the bottom end. Properly designed and managed border strips can reach a field application efficiency of up to 75%, although a more common figure is 60%. With basin irrigation it is possible to achieve field application efficiencies of 80% on properly designed and managed basins, although a more common figure used for planning varies between 60-65%.

In order to show the importance of contribution of Ea to the overall irrigation efficiency while keeping the same Ec and Eb but increasing the field application efficiency Ea from 50% to 70%, an overall irrigation efficiency of 0.57 or 57% (0.90 x 0.90 x 0.70) can be achieved instead of 41%.

The common problems that can reduce the field application efficiency of the three surface irrigation methods are:

- Poor land levelling can lead to waterlogging in some places and inadequate water application in others. If the cross slope is not horizontal for border strip irrigation, water will flow to the lowest side causing over-irrigation in that area.

- Different soil types along the furrows, border strips and basins result in different infiltration rates.
- Too small an advance stream results in too long an advance time, leading to over-irrigation at the top end of the border strip and furrow. A small stream size diverted into a basin will take too long to cover the entire basin area, resulting in a contact time that is very different at the various sections of the basin.
- Too large a stream size will result in water flowing too fast down the border strip and furrow leading to a cut-off taking place before the root zone has been filled with water. If the flow is allowed to continue under these conditions there will be excessive runoff at the end. A large stream size, on the other hand, can be desirable for basins as this reduces the difference in contact time on the various sections of the basin.

3.7. Improved Water management and Scheduling

Currently, no water scheduling takes place on the PIPs, with scheme pumping stations operating as long as available electricity permits. It is recommended that scheduling is introduced into the planning and design stage of the projects and also staffs are trained in how to do this at a practical level during PIP operation. This necessitates the introduction of measuring devices (Annex G) and climate stations such as exists at Shwe Hlan Bo.

In most PIP projects, the quality of irrigation water is good and most soils are sandy with good natural drainage. As a result, soil salinity is not an issue except where there are serious drainage problems. Leaching requirements are therefore generally ignored when estimating irrigation requirements unless salinity problems have been identified. In addition, due to irrigation system inefficiencies, water losses due to deep percolation normally satisfy any leaching requirements.

The gross irrigation requirements account for losses of water incurred during conveyance and application to the field. This is expressed in terms of efficiencies (as discussed earlier) when calculating project gross irrigation requirements from net irrigation requirements, as shown below:

$$IRg = IRn/E$$

Where:

IRg	=	Gross irrigation requirements (mm)
IRn	=	Net irrigation requirements (mm)
E	=	Overall project efficiency

By utilising the FAO Cropwat programme (Annex E), crop water requirements can be determined on a regular periodic basis according to estimated effective rainfall. The program allows for changes in soil type, crops, efficiencies, application methodology etc. This will then give the variation in gross irrigation requirements at the pumping station and unable operators to make a first estimate of how to deliver the irrigation water. This can then be checked against the prevailing climate data and also through actual measurements of the water delivered into the system from the flow measurement structures at different stages of the project. An estimate of the how the delivery is meeting the overall water requirements of the crop can be made and adjustments made for rainfall, feedback from the farmers on problem areas and other issues. Only in this way will the energy use the pumping the use much more efficiently. It does however rely upon the conveyance efficiencies of the canals being reduced by spot lining as required and for the lateral and watercourse canals to be properly constructed and land levelling to be carried out when needed.

3.8. Operation and Maintenance

Currently, no attention is given to operation and maintenance (O & M) during the design process and maintenance in the field is carried out as best as possible considering the marginal allocations that WRUD operators are given. There is a strong need to introduce a systematic approach to O & M on all project sites and this will involve a greater role and participation by the farmers through their water users Association (see Annex H). The tasks associated with each are summarised below to facilitate this process objective of which must be to ensure that greater funds are made available to O & M so that they can be carried out more effectively and cease the mining of the assets and the rapid deterioration of the irrigation schemes.

Operation covers the tasks associated with the physical operation of the irrigation and drainage network and includes:

- Annual/seasonal planning for water delivery
- Deciding on water allocations to water users
- Scheduling of irrigation supplies
- Regulation of control structures to deliver the required amount of water
- Measurement and recording of irrigation water deliveries
- Monitoring and evaluation of irrigation operation (to ensure targets are met)

The objectives for operation of the irrigation system are to supply water:

- In adequate quantity (discharge and duration)
- At the correct time (in relation to crop growth stage and water demand)
- Reliably
- Equitably
- Efficiently
- Cost effectively

The objectives for maintenance of an irrigation and drainage system can be stated as:

1. To enable the system to be operated at its optimum level at all times
2. To ensure the longest economic lifespan of the system and its individual components
3. To achieve the operational and longevity objectives at optimum cost.

Maintenance can be classified into 6 main categories:

- Routine
- Periodic
- Annual
- Emergency
- Deferred
- Preventative

Maintenance work can be carried out under these categories by one, or a combination, of the following:

- Direct labour by water users themselves
- Contractors

3.9. Training and Training Institutions

Current training institutions have no modules relating to irrigation and drainage design. This should be addressed by the introduction of water management training and an irrigated agricultural program aimed not only at the higher levels within MoAI but also at the lower levels targeting WUA/farmer level training. A practical field-based training program needs to be developed that links with established training institutions both within the country and abroad. Several interesting initiatives are planned and if these are combined, will go a long way to improving skills of those involved in the design, implementation and management, operation and maintenance of the irrigation schemes. These good initiatives include the allocation of land and preliminary plans by WRUD for a field-based technical training facility at Shwe Hlan Bo PIP and the targeted training by the Institute for civil, earth and water engineering (ICEWE), Water Sources Training Institute (WRTI) and NEPS in the Yangon (Annex K).

It has been proposed that a core of experts be established in LIFT to support MOAI/WRUD both in the provision of technical inputs and advice but also by providing support to training institutions and courses. Such training should not exclude the agricultural institutions and MAS as is our key change institutions. The modalities for providing such training will need to be determined after the Donors and the Government of Myanmar have discussed in detail the way forward (Section 4). It is how anticipated that support will be made up of national and international specialists, some of whom could be provided in the longer term, but most of whom would provide short-term targeted inputs. Details such as the strengthening of the Farmer Field schools approach could draw upon FAO who have been one of the key drivers in the implementation of this approach. What still remains to be established in this important capacity building and training exercise will be how interventions can be introduced to initially benefit the PIP areas and where they should be introduced, at what level, and the support that will be needed for implementation.

4. Possible Implementation Modalities

The proposals are aimed at achieving quick impacts over the next few years (3 to 5 years) but also at contributing to the longer-term sustainability of interventions. In the shorter timescale, the mechanism developed for LIFT trust fund would seem to be an appropriate means of supporting the softer interventions that the Donors have indicated they could consider supporting[26]. There is no doubt that the skills required in irrigation engineering have been engineering oriented and coupled with the lack of appropriate modules within the training institutions, have removed over time any links with the farmers and agriculture. There will thus be a need to provide technical inputs/advice to support any proposed interventions and this could be achieved by providing a multidisciplinary group of well experienced senior experts, both short or long-term, operating out of LIFT. These services would be provided to MOAI/WRUD/MAS and to NGO service providers. LIFT already has many NGO implementing partners of which about 10 are already dealing with communities within the dry zone. Their skills could be extended to working with the communities in preparation for the arrival of irrigation water but this will need common guidelines and training to ensure that appropriate and proven messages and approaches are adopted. This relates specifically to the expansion of the roles and responsibilities of water users associations.

Capacity building and training will be an essential part of the interventions. This can also be provided through the core of experts proposed for LIFT by providing links with appropriate training institutions (local & abroad) and ensuring that their practical support is linked with delivery of training sessions on how to implement proposals. NGO service providers are equipped to provide emergency and post-disaster support, but few are properly experienced to deal with development issues. It will therefore be necessary to screen the NGO service provider community to identify those who have skills in development or who could, with training, provide the necessary support to the communities. This includes both INGOs and NGOs.

Some of the proposals presented in Table 4.1 are expected to meet the criteria for Donors' areas of support and others that could be supported by the Government of Myanmar. The Consultants' proposals for support are also indicated in the Table. All will be aimed at initiating a useful dialogue between Myanmar and Donors on technical issues that relate to food security and livelihoods in the vulnerable Dry Zone. Government is aware that the softer aspects have been lacking from the past construction dominated interventions and is looking for practical proposals for encouraging such support to result from this mission. If this is achieved, it will assist considerably in the better planning and design of already initiated investments in irrigation projects, and through this, stabilise production and contribute towards overcoming the impact of vagaries in rainfall in the dry zone.

[26] The donor group has already indicated that at this stage it is not considering Investments in physical works.

Figure 13. Matrix of opportunities

No	DESCRIPTION OF IMPROVEMENTS NEEDED	TYPE OF INTERVENTION	OBJECTIVE OF SOLUTION	DELIVERY MECHANISMS	SUGGESTED FUNDING SUPPORT	
					DONOR	GOVERNMENT OF MYANMAR
1.	Planning and design of irrigation and drainage projects that consider better all of the factors involved in the improved sustainability of irrigation and drainage projects that are geared towards greater farmer involvement.	Improvements in the approach to irrigation design.	To enable the implementation of improvements to existing schemes and to avoid similar problems in the future, learning from past experience.	Cooperation with donor community to engage both short-term and longer term experience and specialised consultants to assist with the upgrading of the design manual, the in-service training of WRUD staff and to provide assistance to training institutions.	✔	✔
				Establishment of a core of well experienced technical staff of wide disciplines to provide support both to government and to service providers. This will be a combination of a few longer-term specialists and a range of short-term specialists.	✔	
			Greater cooperation between various different disciplines including involvement of agriculturalists, water management specialists, economists and sociologistsin the design of irrigation projects.	Recruitment of appropriate staff by WRUD and establishment of horizontal links between technical staff in different organisations.		✔
		Improved and More Complete Technial Design Manual	Use of appropriate irrigation methods and improved water management.	Provision of multidisciplinary technical team to work with MOAI/WRUD to provide technical inputs addressing the issues and providing papers for inclusion in the proposed capacity building training programme. This will include Specific targeted short-term training courses together with the introduction of appropriate software.	✔	✔
			A balance between irrigation in the monsoon season and irrigation in the winter and summer seasons considered in relation to funds available to pump irrigation water, the availability of water and the economic design of the systems.			
			Improved economics of designs and selection of water delivery methods and soils to be irrigated.			
			Relationship between pump design and water delivery to crop water needs to provide greater flexibility in operation.			
			Improved computation of crop water requirements and use of irrigation scheduling; utilisation of CROPWAT or a similar program to improve the estimates of crop water requirements. This is particularly relating to other upland crops.			
			Improved delivery of irrigation water within the irrigation system to create more equitable distribution (quantity; time; duration).			
			attention has to be paid to the type of crop to be irrigated, its crop water requirements and the returns that it receives as generally they need to be high-value crops. The aim must be to reduce the current volume of water pumped so that the cost of water is directly related to the value of the crop yield.			
			Introduction of improved drainage designs to avoid potential problems (soils; salimity; etc) within proposed cropping patterns developed.			
		Access to soils and land-use maps to improve irrigation design and appropriateness of methods proposed.	conveyance and application efficiencies and irrigation methods been related to the soils actually experienced on the ground.	government to provide access to the appropriate maps with external support to supplement deficiencies and to update the information available towards irrigated agricultural production.		
			Irrigation developments, irrigation methods and crops grown must be related to the available water and the water holding capacity of soils.			

2.	Improved implementation of irrigation schemes	Extension of financial support provided to include lower-level parts of the system and the resource poor farmers and diligent members.	More timely completion of tertiary and on-farm works including assistance with construction of tertiary canals and watercourses, land levelling and improvement, construction of structures, etc. (materials for cross regulating and offtake structures).	Support for food for work and cash for work for employment of unemployed in villages and as a benefit to the not so well off farmers who do not have the resources to devote the required time for these works due to their needs to take advantage of employment activities elsewhere.	✔	
		Allocation of budget to support a programme of rehabilitation and upgrading of existing systems.	To facilitate more effective water management and to ensure that systems on that are designed for farmer operation and maintenance.	WRUD to review project funding approach and request central government to provide greater budgets for this in the short term.		✔
		Introduction of measuring structures into all existing irrigation schemes to quantify actual amounts of water and diverted and main, distributary and tertiary/lateral canal levels.	To relate actual water supply with the assumed watersupply and to improve water scheduling and water management at field and scheme level.	WRUD to review types of measurement structure available and to introduce standards for these to each scheme.		✔
		Enhancement of the capacity of the field staff to make improvements to design on-site during implementation and to adapt better irrigation system to the existing layouts on the ground.	Rotation of staff between the design office and the field offices so that they can gain practical experience on the problems of implementation at field level.	Appropriate in-service training provided by experience short-term specialists who have inputs at short-term training institutions and also can assist design engineers on a day-to-day basis.	✔	
			site supervising engineers are well equipped to deal with problems that they are faced with.	Improvement in the human resource development within WRUD to ensure that younger staff obtain a much wider range of experience including both design and in the field.		✔
3.	Implementation of farmers' freedom to move away from "policy" crops towards higher margin crops such as oilseeds and pulses, plus greater emphasis on these summer and winter crops.	Implementation of modified policy and lower levels including district and township.	Awareness on the mechanisms for increasing food security by not only producing the crops directly, but by increasing the purchase power of communities through the production of high value crops.	training and education of staff at district level and below on the benefits of the wider variety of crops that could be grown.	✔	✔
	Better delivery of support to farmers to improve their choice of crops and ability to grow and sell them.	Enhanced extension service.	Reorganisation of MAS to be more for farmer oriented and to be provided with appropriate skills to be able to deal with Farmer demands and a wider rangeof crops and services.	Enhancement of the skills both at farm level and higher levels using international proven experience coupled with a series of short-term courses utilising established training material.		✔
			Farm advisory services (FAS) Strategy			✔
			Wider use of Farmer Field schools.			✔
			Introduction of support for alternative higher value crops with lower water requirements per KG of crop produced.		✔	✔
			Improvement of crop yields of or farmers especially the average and poor farmers.			✔
			Selection of crops to be grown in relation to ability of the farmers, suitability of the soils, market demand, irrigation requirements, etc.			✔
			The development of cropping patterns considering the crops recommended and the net returns as developed in crop budgets.			✔
		the availability of seasonal credit seasonal credit.	Linking with other programs designed to improve food security and livelihoods of the rural communities.	Awareness of the scope for support amongst the donors and implementing partners and the need to link with wider programs.	✔	
		Improvement in the quality of seed (Rice and other higher value crops).	Better selection of seeds to improve yields and to reduce length of growing period.	Provision of appropriate technical systems and links with private producers and international organisations dealing in seed.	✔	
		Certified paddy seed production oversight (Annex I)			✔	

4.	Capacity building and training	Introduction of a variety of avenues for improving capacity short-term specialised courses in-country, targeted training of trainers, links with overseas universities with appropriate courses and a few staff attending postgraduate (MSc level) courses abroad in countries like Thailand, Australia and maybe Europe.	Introduce the new ideas into mainline thinking and to ensure the sustainability of interventions and that younger suitably trained professionals are available to follow up from those senior professionals who are soon to retire.	Short-term experienced technical input. Subject matter training specialists in: seeds; crop protection; fertiliser; specialist crop agronomy; livestock; draft animal power; HVH; post harvest and storage. All levels but mainly at PIP level. To be specified in the FAS Strategy Report.	✔	
				Improved short-term technical courses for farmers and field staff.		
				Introduction of irrigation and irrigated agriculture curriculum into established institutions.		✔
				Links with appropriate external institutions (regionally and international).	✔	✔
		Establishment of an improved training in agriculture and irrigation based on a training needs assessment.	Training at senior WRUD and MAS levels in methodology and management; Training of trainers; Training of WRUD & MAS staff at District and PIP level; Training of Lead Farmers in FFS techniques at PIP level in association with MAS & WRUD staff	Enhancement of local training institutions and initiatives, especially in the private sector through capacity building and facilitation of short-term specialists.	✔	
		Specilised support for introduction of input support	Certified paddy seed production oversight & seed quality monitoring	Seed Experts; Short term; Periodic inputs until well established.	✔	
5.	Improved operation and maintenance	Enhanced water users associations	Facilitate the future developments by working to involve WUAs in adapting designs and in the development of water users associations to manage, operate and maintain the tertiary and Watercourse systems.	Targeted short-term technical assistance to provide recommendations to government on improved WUAs and to provide training modules for technical staff on the development, role and functions of water users associations.	✔	
				Use of local INGOs/NGOs who are familiar with the communities and the areas.	✔	
			Maintenance carried out on an as and when needed basis rather than a regular basis. Constraints are addressed when they arise instead of keeping the water moving according to the design	Adoption by government of proposals relating to enhanced water users associations and the improvement of contributions to management, operation and maintenance (MOM).		✔
		Inadequate budget for maintenance and farmer involvement	Establishment of a maintenance program involving the water users associations with greater funding from the government and part funding from the water users associations.	By linking payments with service provided, the farmers can see more clearly where their money is going.		✔
			Enhanced budget for annual maintenance.	Review of water charges and contributions to MOM		✔
		Assistance with the introduction of an asset management approach to maintenance of the system.	Increase maintenance and avoid the gradual deterioration and mining of the Irrigation and Drainage System.	Targeted short-term technical assistance to provide recommendations to government on improved WUAs and to provide training modules for technical staff on the development, role and functions of water users associations.	✔	

5. Way Forward

This report provided by the Consultants represents their analysis of the technical situation in the field and the scope for improving productivity with the goals of greater food security and improved family livelihoods and village level. This report has expanded upon and explained in more detail the findings, conclusions and recommendations presented in the debriefing presentations given in Myanmar and that were summarised in the aide memoire. It has been formulated by examining the existing situation through “new eyes” on the technical problems faced with the overall aim being to increase the overall productivity from the PIP. The main issues of concern have been highlighted and the suggested areas for improvement identified. In Chapter 4, possible areas for support by the Government of Myanmar and the Donors have been suggested and it is hoped that this will lead towards an open a dialogue with the Government of Myanmar to discuss the proposals, findings and possible joint implementation in a timescale to be determined. By encouraging a development oriented and joint approach to improving irrigated developments, it is hoped that a consensus can be reached on how to contribute to the common goal of Food Security and Food Production and to increase the sustainability of interventions on the ground.

During the visit to Myanmar and in the various discussions and debriefing meetings, it was emphasised that the outcome is not a foregone conclusion. However, WRUD has indicated that it is extremely keen on follow-up as soon as possible so that it has something to show to government on the way forward. This positive cooperation should be utilised whilst the opportunity exists.