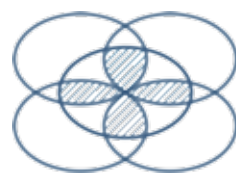


# Spate Irrigation in Myanmar

# 9



Overview Paper Spate Irrigation



Spate Irrigation  
Network



## Introduction

This overview paper highlights the current and potential use of short term floods in Myanmar for productive agriculture. Particular Shan States and the dry zone have high unused potential for spate irrigation schemes: A large number of traditional systems need rehabilitation and numerous sites allow development of new spate irrigation systems. The paper also discusses other flood based irrigation systems.

Myanmar is geographically located between 9° 32' and 28° 31' North Latitude and 92° 10' - 101° 11' East Longitude. It is characterized by mountain ranges in the north, east, west and a long coastal strip in the south.

It stretches about 2,061 kilometer from north to south and approximately 945 km from east to west. Myanmar's territory covers 67.66 million hectares.

According to the statistics of 2011-12 the population of the country is estimated at 60.4 million and the population growth rate is 1 %. It has seven states and also seven regions. These are presented at figure 1.

It has international borders with China in the north, with Thailand and Laos in the east, with India and Bangladesh in the west and again with Thailand in the south.

Table 1: Myanmar at a glance (Source: Ministry of Agriculture and Irrigation, 2011)

Location	
Latitude:	9° 32' - 28° 31'
Longitude:	92° 10' - 101° 11'
Land frontier:	
with Thailand	2099 km
with Laos	235 km
with China	2227 km
with Bangladesh	272 km
with India	1453 km
Sea frontier	
Rakhine coastline	713 km
Delta coastline	438 km
Tanintharyi coastline	1078 km

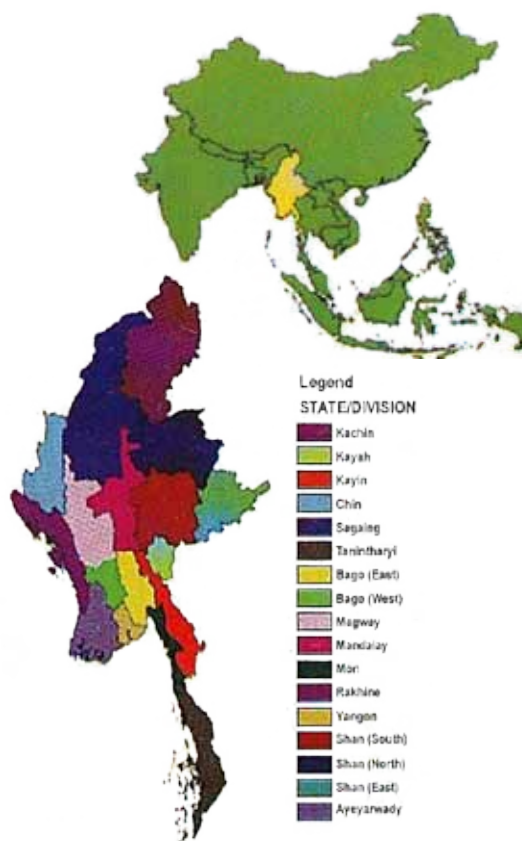


Figure 1: Location of a) Myanmar in Central Asia and b) its national distribution of states/divisions

The country may be broadly divided into three agro-ecological zones.

- The “wet zone” in the southern coastal and delta area, including Yangon, Ayeyarwady, Bago, Tanintharyi regions; and Rakhine and Mon States (26 % of the land).
- The “dry zone” of Central Myanmar, including Magwe, Mandalay and Sagaing regions (26 % of the land).
- The intermediate areas including, Kachin, Kayah, Kayin, Chin and Shan States (48 % of the land).

Generally Myanmar has three seasons:

- The rainy season extends from May to October when the moisture-laden southwest monsoon blows from the Indian Ocean. During this season there is frequent heavy rainfall, accompanied by high humidities and cloud cover. Temperatures are moderate.
- A cooler, dry season, lasts from November through February.
- The hot season is from March to May.

Monthly average<sup>1</sup> temperature and rainfall at selected stations are shown in figure 2.

1) Average are over the period 2000 - 2009

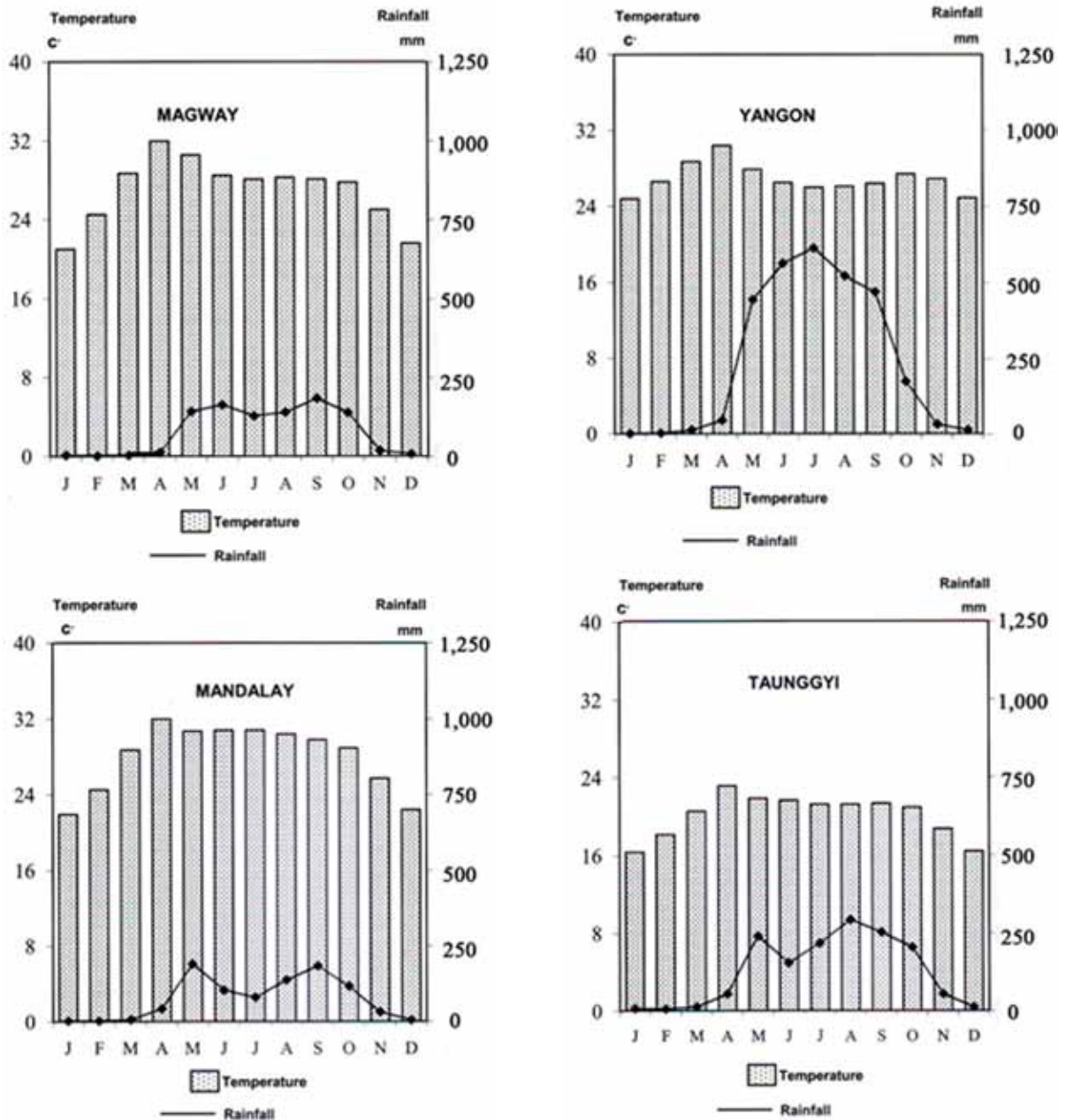


Figure 2: Monthly temperature and rainfall over 2000 - 2009 (Central statistical organization, Myanmar, 2010)

In the central dry zone areas, crop failures, through droughts, are common even during the rainy season. Throughout most of the dry zone, the surface water sources are ephemeral and dry up between December to April. The small rivers tend to have wildly fluctuating discharges.

Now-a-days, due to climate change, the occurrence of rainfall varies in intensity and time over the year and is different between the regions.

Therefore, spate irrigation – diversion of floodwater through hydraulic structures and canals to spread water over the agricultural lands – is the most cost effective solution for irrigation,

especially in the dry zone and Shan States. In these areas spate irrigation systems have been successfully implemented since 1997 under UNDP/FAO projects.

Currently one project, in Mandalay Region, is being implemented by the Water Resources Utilization Department (WRUD) of the Ministry of Agriculture and Irrigation (MoAI). Another spate irrigation project has just been completed in Sagaing Region, where pumping facilities were installed to pump spate water from the streams for irrigation.

## Potential Sources for Spate Irrigation

Irrigation has a long history in Myanmar, being practiced since the time of the ancient Myanmar Kingdom. Construction of irrigation works, especially storage tanks, diversion weirs and canals for crop cultivation started over a millennium ago. Rehabilitation works of many old irrigation systems were carried by the British rulers during the colonial period in the late 19<sup>th</sup> and beginning of the 20<sup>th</sup> century.

### Land Resources

The total area of Myanmar is 67.66 million hectares and current land use distribution in 2011-12 is shown in table 2.

Table 2: Land use distribution in the 2011 - 2012 season (Ministry of Agriculture and Irrigation, 2012)

Sr No	Type of land	Land use (million ha)	Percentage %
1	Net sown area of crop land	11.92	17.60
2	Current fallow	0.32	0.50
3	Cultural waste	5.37	7.90
4	Reserved forests	18.24	27.00
5	Other forests	15.35	22.70
6	Unclassified land not suitable for crop land	16.46	24.30
<b>Total</b>		<b>67.66</b>	<b>100</b>

Remark: Total cultivatable area is 17.61 million hectares, which is 26 % of total land area.

At present, less than 20 % of the land - 11.92 million hectare - is used for agricultural production. Other land use types, as presented in table 2, suitable for crop production are 0.32 million hectares of fallow land and 5.37 million hectares of cultural waste land. Both land resources could increase current productive area over 50 %. Therefore, the potential for further expansion of land resources is enormous.

On average 2.2 million hectares of crops are irrigated each year. As presented in table 3, the irrigated area is stable in the last five years, but is limited to only 16 % of the agricultural area.

Out of the net sown area of 13.58 million hectares in 2011 - 12, the irrigated area was limited to only 2.12 million hectares. The drop was caused by limited rainfall in the dry zones, through which only 15.6 % could be irrigated. There is large potential to increase irrigation and increase agricultural production.

Table 3: Net sown area and irrigated area (Irrigation Department, 2012)

Sr No	Year	Net sown area (million ha)	Irrigated	
			area (million-ha)	Percentage of irrigated area %
1	2007-08	13.22	2.25	17.02
2	2008-09	13.49	2.27	16.86
3	2009-10	13.64	2.33	17.07
4	2010-11	13.75	2.29	16.70
5	2011-12	13.58	2.12	15.60

Remark: Year 2012 has less rainfall especially in dry zone.

Table 4: Annual average estimated surface water and catchment areas (Ministry of Agriculture and Irrigation, 2011)

Sr No	Name of Principal River Basin	Catchment area km <sup>2</sup>	Average estimated annual surface water (km <sup>3</sup> )
1	Chindwin River	115.30	227.920
2	Upper Ayeyarwady River (up to its confluence with Chindwin River)	193.30	141.293
3	Lower Ayeyarwady River (from confluence with Chindwin to its mouth)	95.60	85.800
4	Sittoung River	48.10	81.148
5	Rivers in Rakhine State	58.30	139.245
6	Rivers in Tanintharyi Division	40.60	130.927
7	Thanlwin River (from Myanmar boundary to its mouth)	158.00	257.918
8	Mekong River (within Myanmar territory)	28.60	17.634
<b>Total</b>		<b>737.80</b>	<b>1,081.885</b>

**Water Resources**

The catchment area of Myanmar’s eight principle river basins comprise about 737,800 km<sup>2</sup> and the average annual in-flow of surface water is 1,082 km<sup>3</sup>. Table 4 shows the general statistics for the individual catchments. Current utilization comes to only about 39.55 km<sup>3</sup>. Therefore, the scope for further expansion of water resources utilization is tremendous.

The occurrence of rainfall varies in intensity and time of year and is different between regions. An isohyetal map of Myanmar is shown in figure 3. It shows that annual rainfall is lowest in the Central dry zone with 760 mm; also in some areas of Shan State rainfall is low, not exceeding 1,520 mm. In these areas, spate irrigation is required to increase agricultural production.



Figure 3: Isohyetal map of Myanmar (Annual Rainfall in millimeter)

At the moment some 1,000 village level spate irrigation schemes, usually small tank and diversion weirs, have been completed throughout the dry zone region with estimated irrigable area of 73.500 hectares of agricultural land. The systems were constructed and financed by farmers and the Irrigation Department. Farmers provided free labour for up to one third of the project costs. The Irrigation Department provided machinery and finance for the construction of the more complex civil works, such as diversion weirs and regulation structures. Especially in the dry zone these works could be rehabilitated as spate irrigation systems, for efficient and effective water distribution.

Further, spate systems are largely unknown and not well surveyed, despite the large potential of spate irrigation in Myanmar. Therefore, preliminary studies should be carried out to map high potential spate sites. This applies particularly the dry zone and some parts of Shan State areas. Both areas have a large irrigation potential and have also good accessibility in terms of infrastructure.

**Spate Irrigation Systems**

**Spate Hydrology**

Most of the small streams in Myanmar, especially in spate irrigation areas, are ungauged. Therefore discharge observations are hard to obtain and are often not available at all. For the design of spate irrigation systems, estimation of “design” flood and estimation of run off or “yield” from a catchment are critical.

Estimation of the design floods, for an entire ungauged area, is among the main challenges for the spate irrigation system designers in Myanmar.

**Estimation of Design Flood**

Estimation of the design flood should be carried out on the basis of hydro-metrological observation and analysis. But adequate data, as mentioned above, is often not available for all streams. It can however be estimated by indirect methods or empirical methods. The following methods are used for design flood calculation, based on rainfall data of 20 years or more.

Rainfall data should be those of a representative rainfall station in the catchment. If such data is not available, data of similar adjacent stations is taken and corrected to the values of the station of interest.

Rainfall frequency analysis is carried out with Gumble, Log Normal or Log Pearson Type III distributions to determine the best fit and adopt a distribution. For extreme conditions, Gumble's distribution is the most suitable.

The following methods could be used for the design flood calculation:

### Rational Method

In this method the runoff is correlated with the rainfall and catchment characteristics. This method is based on a design rainfall intensity. For the design of diversion weirs rainfall intensity of 100 years return period is normally adopted. For other irrigation structures 50 years return period is usually adopted. Time of concentration is calculated based on Kirpich formula.

Usually 24 hour rainfall records are available from metrological stations and these are used to interpolate the rainfall intensity. It may be assumed that the design storm duration be made equal to the time of concentration. The Hydrology Branch of Irrigation Department (ID), Ministry of Agriculture and Irrigation (MoAI), has carried out a project in which regional rainfall depth-duration frequency relationships were determined for the different zones in Myanmar. As part of this project the ratio of design rainfall duration in minutes to one day rainfall (in minutes) were analysed. The "K" values for the dry zone and Shan State was determined to be 0.3.

The relations between the runoff coefficients and soil types are presented in table 5.

Table 5: Values of runoff coefficient (Irrigation Department; MoAI)

Sr No	Type of catchment	K values	
		Large	Small & steep
1	Rocky and impermeable	0.8	1.0
2	Slightly permeable, bare	0.6	0.8
3	Slightly permeable, partly cultivated or covered with vegetation	0.5	0.7

### Regional Flood Study

Regional flood frequency relationships are widely used for flood estimation of ungauged catchment areas.

Based on the annual flood records of rivers and streams of central dry zone regions, the Irrigation Department developed a formula to calculate the **mean annual floods** of the catchments.

The specific flood discharge of desirable peak flood return periods can be computed by multiplying the mean annual specific flood with the factor shown in table 6, derived from hydro-meteorological analysis.

### Catchment Area Formula

No formula, based on catchment area, can take all varying factors into account. Generally these formulae try to account for all variables by one composite coefficient. Such formulae have however a limited applicability for calculations at regional level. Field data of concerned regions is required for validating the formulae.

Dicken's formula is very straightforward in use, but the choice of coefficient "c" should be picked with careful considerations.

### Slope Area Method

If measures of maximum experienced flood discharges, estimated on the basis of flood records or flood mark survey, are available, they should be taken into account. The highest water marks should be verified with the help of local farmers and villagers. Based upon their observations the slope-area method can be used to estimate the mean flow velocity, assuming that the flow in the selected reach of the river is hydraulically uniform. Cross section and longitudinal surveys has to be carried out to obtain these hydraulic characteristics. The mean flow velocity is usually determined by using the **Manning equation**.

### Estimation of run off or yield

Estimating catchment run-off is most reliable when actual stream flow observations are available.

Table 6: Multiplication factors of probability (Irrigation Department MoAI)

Return period years	Multiplication factor
100	2.95
200	3.41
1000	4.09

In the absence of such data, the only resource left is to compute the run off as a percentage of rainfall. In Myanmar the run off coefficient ranges generally from 0.14 (14 %) to 0.2 (20 %). This way, annual yield or monthly inflow can be estimated.

Based upon the monthly and annual run-off, the irrigable area can be estimated using the crop water requirement. Monsoon paddy is the most common crop in many parts of Myanmar. Therefore irrigable area is estimated based on crop water requirement of monsoon paddy rice.

### Sedimentation

Nature of sedimentation depends on fundamental elements such as meteorology, topography, geology and vegetative cover of the catchment area. It is therefore very difficult to estimate exactly the sediment volume.

In spate irrigation systems in Myanmar, a portion of the smaller floods are diverted and allowed to flow to the fields. Coarse sediments are settled in the river channels and irrigation canals, and finer sediments are deposited on the fields. These deposited finer sediments become natural fertilizer and are useful for the farmers. In some parts of Shan State area, farmers developed the habit to divert the first flood(s) to their fields, to obtain natural fertilizer such as burned ashes, cow dung and finer top soil etc.

The Irrigation Department has estimated annual sediment erosion rates in eight region of Myanmar and equal value lines in acre-feet per square mile are mentioned in figure 4.

### Water Diversion Structures

In spate irrigation system, flood water from streams and rivers is diverted and distributed to farmer fields. Therefore, diversion structure stability is very important in spate irrigation. The most traditional types of diversion structures include diversion weirs, spur type deflectors and diversion dams. Usually traditional types of weirs are constructed with wooden logs and stones. Spur type deflectors are constructed with wooden logs embedded into the river bed and brush woods are filled up, in between the rows of wooden logs. It is known that, during the days of Myanmar kings, diversion dams were constructed with earth and compaction was carried out with elephants. Type of diversion structures depend on characteristics of the stream and topography of

the irrigable area.

In spate irrigation systems, the objective is to divert the maximum possible amount of water to the fields during the very limited spate flood period, ranging from a few hours to a few days. Diverted water will be stored in the fields by earthen bunds.

There is no single approach for the design of improved spate irrigation systems. However, for weir design usually the standard equation of the broad crested weir formula is used. The design of the structure is usually based on the "100 year return flood". A vertical drop type of weir body is adopted for small weirs and ogee type is adopted for medium and large size of weirs.

To calculate the length of the weir, specific discharge or unit discharge passing over the weir is adopted for the assigned design discharges. Usually for a small weir unit a discharge is taken of 4 to 5  $\text{m}^3\text{sec}^{-1}\text{m}^{-1}$ . For medium and large weirs, a unit discharge of 8 to 9  $\text{m}^3\text{sec}^{-1}\text{m}^{-1}$  is adopted. The cost of overall weir appurtenant structures and associated energy dissipation arrangements increase when specific discharges increase. **The general recommendation is to avoid high specific discharges and large head drops, and to adopt sufficient head** to achieve effective sluicing and to maintain required command over the area to be irrigated.

Potential scour is usually calculated using **Lacey Formula**, which is simple in use. Scour depth is calculated using a scour multiplication factor of 1.5 for the upstream part and 2.0 for the downstream part of the structure. The **Bligh or Lanes** weighted creep theory is used to determine the length of the structure and depth of the cut-off. The creep length should be greater than the maximum head difference multiplied by the creep coefficient. Creep coefficients are selected based on the soil type of the foundation of the material.

Stilling basins are located downstream from weirs to dissipate energy and to reduce the scouring affect of high velocity flows. The length of downstream floors is calculated based on the hydraulic jump formula and the jump must be within the concrete floor area. The weir body and retaining wall are designed with masonry works, while the up and downstream floors are constructed out of concrete. Just at the end of the concrete floor, concrete blocks and stones with inverted filters are installed to prevent scouring of the down and upstream floor.

Simple structural design is used so that the weir can be constructed with local materials and local



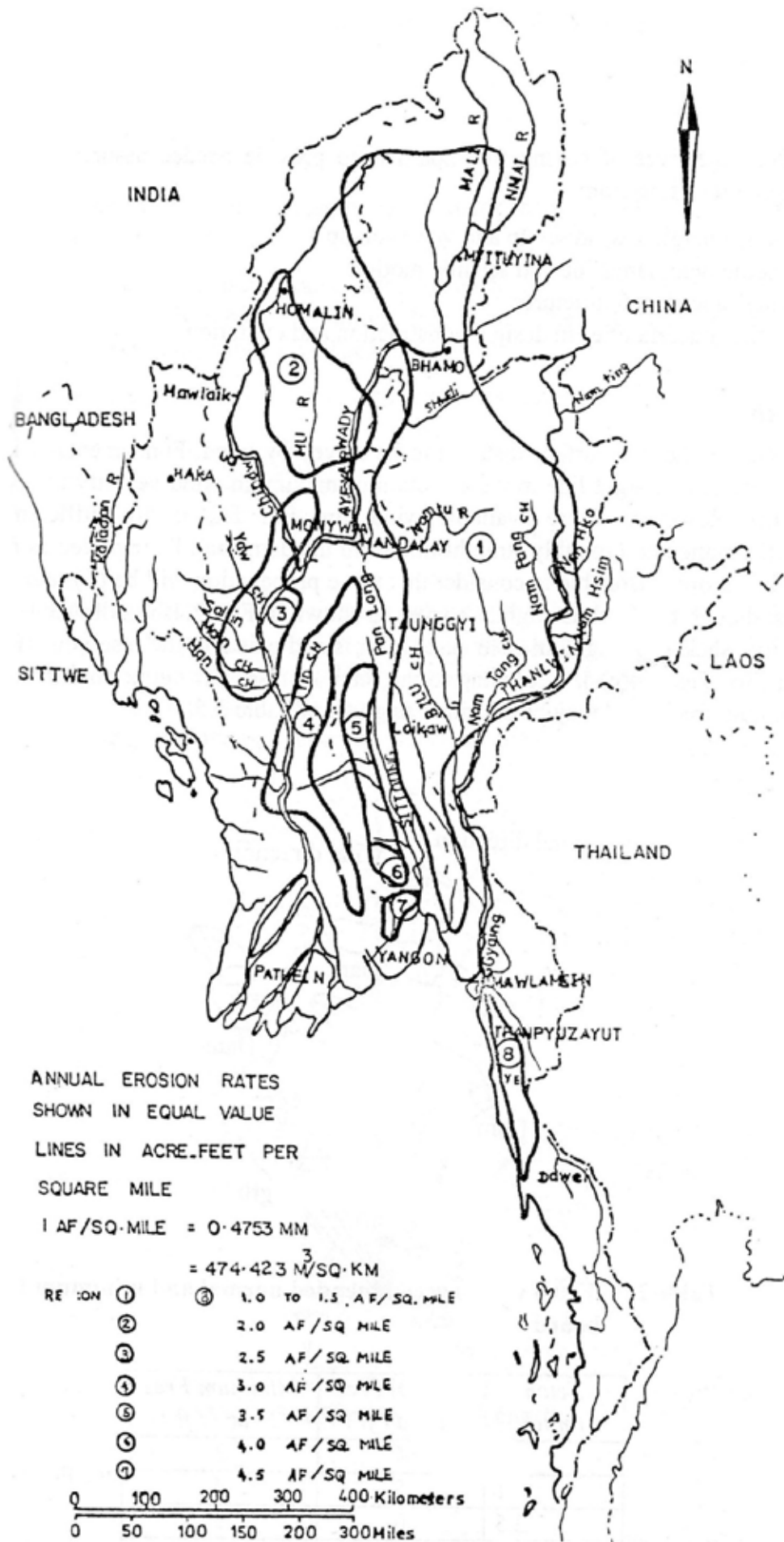


Figure 4: Annual erosion rates shown in equal value lines acre-feet per square mile. (Irrigation Department, MoAI)



Figure 5: Weir structure, head regulator and silt excluders of Shwe Hlan Bo Region Greening Project

skilled laborers. Doing so, indigenous knowledge is used and villagers' participation is strong. For medium and large weirs undersluices are constructed for removal of coarse sediments in the river bed above the weir. Sluices can usually only be operated for the short period of time when the river flow exceeds the canal discharge, which is especially during flood periods. As a result the usefulness of the sediment sluices is limited, whereas they are very expensive to construct. Therefore, for small weir structure, silt excluders are used for removal of the deposited sediments in front of the weir. Silt excluders are very effective and less costly, especially in small diversion weirs.

### Water Supply Canals and Related Structures

In spate irrigation canal systems, the objective is to divert the maximum possible amount of water to the field during the limited spate period. Therefore, intakes and canals have a much larger discharge capacity per unit irrigable area, than is

the case in perennial irrigation systems.

Canals and related structures are designed based on design discharges. In Myanmar, usually a design irrigation duty of 50 acres/cusecs (1,41 l/s/ha) is used. This applies especially to arid and semi-arid regions in perennial rivers. Duties of the spate irrigation systems range from 10 acres/cusecs to 20 acres/cusecs (7 to 3.5 l/s/ha). A conventional "regime" velocity of canal design method is used for perennial irrigation systems. But in spate irrigation canals, discharge varies rapidly according to the spate flow duration. Therefore, the regime velocity concept can not be applied as in conventional methods. Also the size of spate canals is larger and the bed slopes are steeper than the conventional designed canals, so as to carry large discharges, with high sediment, during the spate period.

Modern spate irrigation systems consist of main distribution canals, minor canals and water courses. The canal alignments are designed, starting from the main canal up to water courses in the field. In this way, all canals are able to work at full supply level, which is based on topography, canal type and location of the related structures. In general, the irrigable area of one water course is about 40 to 60 hectares. For minor canals, the irrigable area is about 200 hectares. The capacity of main canals and distributaries depends on topography and irrigable area. The location of completed Spate Irrigation System in Myanmar is presented in Figure 6.

The water controlling and conveying structures of the open channel system, such as bifurcations, checks, drops, culverts, cross drainage works, syphons and bridges must be selected so as to ensure the purpose and function of the entire canal system in consideration of safety

#### Box 1 Flood Based Tidal Irrigation System in Delta Area

Besides spate systems in dry areas, the flood-based systems in the Ayeyarwady Delta Area, dual-purpose canals were designed and constructed for irrigation as well as drainage. At the end of monsoon season, usually in November and December flood water in the canal is controlled by sluice gates to raise water level so as to irrigate adjacent areas by gravity and stored in the paddy fields by earthen bunds. River water level rises up due to tidal effect and this level is higher than the ground level of irrigable area. During high tide level, fresh water from the river is supplied by the canals through the sluice gates. In Ayeyarwady region near Yangon, one tidal irrigation system was implemented at Pan Hlaing river and successfully irrigating about 9,000 hectares of paddy land since 1995. The sluice serves for dual purpose-discharging polder water into the river during November to December and irrigating river water during spring tide in January to May. Just like spate irrigation, river water can be supplied in a few hours during high tide periods. Therefore sluice and canal size are comparable to conventional irrigation system.



Figure 6: Location of completed spate irrigation system in Myanmar

and economy of the structures. Topographical, geological, natural and social conditions, such as land utilization, along the canal alignments are also considered. Many of the water control and distribution structures used in the improved spate irrigation systems are similar to those used in conventional perennial irrigation systems. There are, however, additional features that have to be considered in spate irrigation systems:

1. Simple structural designs are practiced, so that local available construction materials, such as sand, gravel, stone and bricks can be used.
2. Maximum design discharges are used for the design of irrigation canals and related structures. Usually a 10 - 20 % was added to the design discharges of constructed canal and structures.



Figure 7: Bifurcation structure of pump canal and weir right main canal

In the dry zone area near Mandalay city, Shwe Hlan Bo region, a conjunctive water use project is now implemented combining pump and spate irrigation to re-green the region. In the project diversion weirs are constructed in tributaries upstream of the irrigable area. From here, spate irrigation canals lead to the irrigable area. In addition a water pump system is constructed along the main river to pump excess water in irrigation canals, which are connected with the spate canals. The pumps will provide supplementary water to the spate irrigation area, when and where required. Common crops in the spate irrigation schemes are paddy rice (produced in the monsoon and summer season), wheat, cotton, pulses and oil crops.

Figure 7 shows a bifurcation structure of the pump and spate irrigation canal of the Right Main Canal.

## Policy and Procedures of Implementation

Water is a unique natural resource and it is also a finite one. Irrigated land is twice as productive as rainfed cropland. As mentioned in FAO's publication 'Water for Life' one-sixth of the world's cropland that is irrigated produces about a third of the world's food.

### Policy

To establish food security, increased crop production is important. Sufficient water supply and proper water management are the most important factors to allow for this. The main objective of spate irrigation is to create sustainable food security and income earning opportunities for a large number of



Figure 8. Water Users Group meeting at Ywabo village, part of Shwe Hlan Bo Region Greening Project.

farmers and poor people in the project areas. After implementation, maintenance and water management works will be carried out by the people.

There is still considerable scope to expand the area under spate irrigation and to optimize the performance of existing systems. There is also scope to explore spate irrigation techniques that have served other countries well, such as bed stabilizers, conical abutments and soil diversion bunds – so as to expand the list of options and to work in a cost effective manner.

The following guidelines are followed in design of spate irrigation schemes:

- Planning, feasibility studies and implementation processes will be carried out with a participatory approach including villagers and all stakeholders, to create a sense of ownership and commitment to the project.
- Construction materials should be locally available as far as possible. Design of structures must be simple and structurally strong so that they can be constructed with local available materials and local skilled laborers. This allows enhancement of indigenous knowledge and villagers' participation will be stronger.
- If Water Users' Group (WUG) are not existent, they will be formed including village authorities, stakeholders and farmers. Participatory Irrigation Management (PIM)

has to be carried out with WUG's and beneficial farmers in consultation with village authorities. Irrigation Management Transfer (IMT) has to be carried out for operation and maintenance of the irrigation and drainage systems. Farmer trainings will be provided on rules and regulations of operation and maintenance works in spate schemes. Farmers to farmers learning and observation tours to existing spate irrigation systems are part of these trainings. It appears that such tours are effective means to improve operation, maintenance and water distribution methods in spate schemes.

- All works will be carried out with participatory and bottom up approach.

The works should be technically feasible, environmentally, economically and socially viable.

### Procedures of implementation

The following procedures will be used in feasibility studies, field surveys, design and implementation of the spate irrigation systems:

- Based on village meetings with WUG's, Township and Village Administrative Authorities, possible sites for spate irrigation system will be discussed and preliminary data collection will be carried out.
- Based on above discussions, possible sites will be identified and a reconnaissance survey will be carried out.
- If the proposed site is suitable for feasibility studies, then project staff, along with WUG members, will carry out detailed topographical, geological and soil surveys, as well as conduct a hydrological investigation.
- If above studies show feasibility, a detailed design study will be performed, including: detail drawings, a detailed list of required construction materials and labor requirements, estimated costs. These inputs will serve the final implementation.

Above steps have been designed to guarantee that the land and water resource of a catchment area will be assessed carefully before construction of a spate irrigation system. This allows best use of resources, only when benefit is showed in feasibility studies.

## Conclusions and Recommendations

The government of Myanmar places a high priority on the development of rural areas. Myanmar's government is now implementing rural development and poverty alleviation activities. These include provision of loans to farmers, the provision of irrigation, the application of modern agro-technologies: improved seeds, fertilizers and crop protection agents.

Out of the above activities, sufficient and timely water requirement is the most important factor for increased in agricultural production and food security. Therefore, spate irrigation will play a major role in complementing the rural development and food security efforts of the government. This applies especially in the dry zone and Shan State area.

Previous spate irrigation projects, showed beneficial impacts. Past works include the Integrated Community Development Project (ICDP) from 2003 to 2007. The works were carried out with UNDP inputs and villagers participation. During this project six spate irrigation systems in the 'dry zone' irrigate now 290 hectares of land. In Shan State area, 24 spate irrigation works irrigate now 1,900 hectares of agricultural land.

At present the Water Resources Utilization Department, under the Ministry of Agriculture and Irrigation, is implementing two spate projects:

1. Shwe Hlan Bo Region Greening Project, in Mandalay Region. As detailed above this project combines spate and pump irrigation systems to supply water to productive sites. After implementation it will irrigate about 2,000 hectares of agricultural land and will supply domestic water use for the nearby villages. It will also improve greening environment.
2. In Ye-Budalin area of Sagaing Region, the pumping system for diverting spate water from the stream to irrigation canals has been completed and is now irrigating 1,600 hectares of agricultural land.

It is suggested that small scale spate irrigation is explored further in the dry zone and Shan State area. The climate soil, geological and transportation conditions are favouring the conditions for successful spate irrigation systems. Community involvement will be critical part of the exploration studies. The international trend of IMT is also visible in the irrigation sector of Myanmar.

The participatory approach offers new and promising ideas for appropriate and sustainable development of spate irrigation systems. Therefore peoples' participation in planning, design implementation, monitoring and evaluation, maintenance works, will be actively promoted, as to benefits the development of Myanmar's irrigation sector.

## References

Central Statistical Organization, Ministry of National Planning and Economic Development  
*Statistical Yearbook 2010, Nay Pyi Taw Myanmar - 2012*

Department of Agricultural Planning, Ministry of Agriculture and Irrigation  
*Myanmar Agriculture at a glance - 2011*

FAO, Bangkok, Thailand  
*How design, Management and Policy affect the performance of Irrigation Project - 2002*

FAO, Rome.  
*Legislation on Water Users' Organization - 2003*

Irrigation Department, Ministry of Agriculture and Irrigation  
*Out line of the Irrigation Department. October 2012*

Irrigation Department, Ministry of Agriculture and Irrigation  
*Design Criteria on Fill Dam - 1997*

Irrigation Department, Ministry of Agriculture and Irrigation  
*Design Criteria on Headworks - 1997*

Irrigation Department, Ministry of Agriculture and Irrigation  
*Design Criteria on Canal Works – 1997*

Irrigation Department, Ministry of Agriculture and Forest  
*Small Scale Irrigation Sector Project, Asian Development Bank – 1986*

RozgarBaban  
*Design of Diversion Weir Small Scale Irrigation in Hot Climate – 1995*

United Nation of Technical Co-operation  
*Design of low head hydraulic structure – Water Resources Series No. 45*

UNESCO – IHE  
*Spate Irrigation Network, overview paper Spate Irrigation.*



**Colofon**

This Overview Paper is prepared by Eng U Maung Maung Htay, NEPS (National Engineering and Planning Services), [information.neps@gmail.com](mailto:information.neps@gmail.com)

The Spate Irrigation Network supports and promotes appropriate programmes and policies in spate irrigation, exchanges information on the improvement of livelihoods through a range of interventions, assists in educational development and supports in the implementation and start-up of projects in spate irrigation.

For more information: [www.spate-irrigation.org](http://www.spate-irrigation.org).

