

**Background Paper No.1**  
**Myanmar Bio-Physical Characterization:**  
*Summary Findings and Issues to Explore<sup>1</sup>*

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## **LIST OF ACRONYMS AND ABBREVIATIONS**

ACIAR	Australian Centre for International Agricultural Research
ADB	Asian Development Bank
Ag	agriculture
CSO	Central Statistical Organization
EC	European Commission
ENSO	El Niño-Southern Oscillation
EPA	Environmental Performance Assessment
FAO	Food and Agriculture Organization of the United Nations
GDP	gross development product
GEF	Global Environment Facility
GIS	geographic information system
Ha	hectare
HEWS	hazard early warning system
HYV	high yield variety
IHLCS	Integrated Household Living Conditions Survey
IIASA	International Institute for Applied Systems Analysis
IMP	Integrated Pest Management
IRI	International Research Institute for Climate and Society
IRRI	International Rice Research Institute
ISRIC	International Soil Reference and Information Center
Kg	kilogram
Km	kilometer
LIFT	Livelihoods and Food Security Trust Fund
MIMU	Myanmar Information Management Unit
MW	mega watts
NASA	National Aeronautics and Space Administration
NBSAP	National Biodiversity Strategy and Action Plan
NGO	non-governmental organization
PDO	Pacific Decadal Oscillation
RIMES	Regional Integrated Multi-hazard Early Warning Systems for Africa and Asia
SEDAC	NASA Socioeconomic Data and Applications Center
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
USAID	United State Agency for International Development
USDA	United State Department of Agriculture
USG	United States Government
WFP	World Food Programme
WWF	World Wildlife Fund



## **1. INTRODUCTION**

This report provides a summary of key findings from research on food security and the agriculture sector in Myanmar. The focus is on material relevant for a bio-physical characterization of the country. As such, there is little emphasis on material primarily addressing socioeconomic, policy, or institutional aspects of agriculture and food security. This study is based solely on desk research, and it does not involve a field research component. The report is organized by topic, with each section including a bulleted list of significant summary points followed by a brief list of critical gaps or issues to explore during the field mission to Myanmar in November 2012.

## **2. AGRICULTURE AND CROP PRODUCTION (STATUS AND TRENDS)**

Agriculture accounts for about 40% of the country's gross development product (GDP), about 70% of employment and between 25%, and 30% of exports by value. The share of the agriculture sector as a component of the country's GDP has declined over the past decade, constituting 57.1% of GDP in 2001, and 36.4% in 2010 (ADB 2012b). The sector has grown on a year-by-year basis over the past decade. Between 2001 and 2005, growth reached as much as 21.1%, but slowed in 2008, in part due to the destruction caused by Cyclone Nargis (ADB 2012b).

As of 2009, the net crop coverage is 11.67 million hectare (ha); accounting for 18% of the total land mass with approximately 5.7 million ha (8.4% of total area) still available for expansion (FAO/WFP 2009). Kachin, Shan, and Chin States are promising options for future agricultural expansion.

According to the FAO/WFP (2009), the food crop subsector on its own makes up 80% of the total value of sector production. Among the food crops, a major share of land was sown with paddy, although that share is in current decline. In 2006/07, the paddy area was approximately 8.1 million hectares, accounting for some 40% of the total area sown. Approximately 18-20% of the rice production comes from the summer crop season, while the majority comes from the monsoon paddy season.

Maize is one of the main staple foods after rice in some regions, like Chin State. Overall, maize cultivation covered 346,000 hectares in 2007/08 including Sagaing Division, north and south Shan State, Chin State, and Magwe Division. The highest yields were recorded in Kayin State, Ayeyarwady Division, and Shan State (north). The highest producers of maize were Shan State (north), Sagaing Division, and Shan State (south). Pulses are consumed almost daily in most areas of Myanmar, especially in dry-zone regions. Pulses are also becoming an important export crop and more than 1 million tonnes of pulses have been exported in recent years (FAO/WFP Crop and Food Security Assessment 2009).

The horticultural group, including fruits, is of some importance in Myanmar, accounting for almost one million ha (2002). Among the most important individual crops are chilies, onions, and plantains. Horticultural crops are of particular importance in the highland areas of Sagaing and Shan State, where higher precipitation levels allows for intensive, year-round production (UNDP Agriculture Sector Review 2004).

Cropping systems and patterns vary according to agro-climatic conditions. In the irrigated areas, paddy-paddy or paddy-pulses-paddy patterns dominate. In the Dry Zones and other upland rainfed areas, the mixed cropping or intercropping of pigeon pea with sesame or peanut or other pulse patterns are practiced. In mountain or hilly region's upland paddy, maize, millet, oil crops, and pulses are also grown. Many farmers still practice shifting cultivation in these areas. Fruit crops and vegetables are grown throughout Myanmar all-year-round (FAO/WFP Crop and Food Security Assessment 2009).

The majority of paddy areas grown in Myanmar use high yield variety (HYV) seeds. In 2007/08, 61% of monsoon paddy was sown using HYV paddy seeds and about 1% was sown using hybrid paddy seeds. Shan (north) grew the largest area of hybrid paddy among all states and divisions in Myanmar because these seeds are easily procured from the border with China. Almost 100% of the summer paddy was sown with HYV and the remainder with hybrid seeds. Moreover, 54% of the total maize areas sown used hybrid maize seeds and 28%



used HYV maize seeds. Farmers are currently sowing local maize varieties in up to 18% of total maize cultivated areas. Shan State (both north and south) and Sagaing Division have the highest hybrid maize cultivation among all states/divisions (FAO/WFP Crop and Food Security Assessment 2009).

The 2004 UNDP Agriculture Sector Review suggests three main potential avenues for growth in crop production: intensification of production, expansion of the cropped area, and diversification to financially more rewarding combinations of crops. They suggest that only intensification will give a significant boost to crop production and farm incomes in the short to medium term.

As of 2004, with few exceptions, increases in output have been driven largely by increased sown area; generally the result of a switch from other crops rather than opening up of new territory, although this latter may have occurred in more remote areas especially for the oilseeds. Yield improvements have been limited; even an overall growth of 50% over a ten year period implies only 4% improvement per annum, and most crops have not managed even that. In fact, eight of the 12 highest performing crops in Myanmar over the last decade achieved yield increases averaging less than 2% per annum (UNDP Agriculture Sector Review 2004).

## **2.1. Gaps/Issues to Explore**

While the FAO/WFP Crop and Food Security Assessment in 2009 following Nargis provides valuable paddy and other crop figures broken down by state/division, there seems to be little quantitative (and limited robust qualitative) data on the changing crop patterns disaggregated to states/divisions (or more local) through time, particularly over the past decade. It would be valuable to get a better sense of any trends and their drivers (e.g., changing climate, soil properties, seed availability, market conditions, or government programs).

There is discussion of expanding agricultural production through expanding cultivated land. There are suggestions to conduct a review of suitable cultivatable wastelands and other areas that may be able to be converted, with areas in Kachin, Shan, and Chin perhaps being most promising.

Increases in crop productivity, particularly for rice and maize but also for others, seem to have slowed significantly since the 1980s and has stagnated for some crops. There is limited explanation of why this has occurred. Though seeds, soil degradation, changing climate, and decreasing fertilizer availability have been proposed, there is a need for further research.

### **3. FOOD SECURITY AND NUTRITION**

According to the Integrated Household Living Conditions Survey (UNDP 2007), 10% of Myanmar's population is below the official food poverty line. However, there are important differences between states/divisions, with a very high poverty level in Chin State (40%), and a high poverty level in northern Shan State (21%), and eastern Shan State (20%). The headcount index of food poverty is generally higher in states than divisions and higher in rural than urban areas. Lack of access to sufficient food throughout the year is the primary driver of food insecurity. Depending on the area, strong correlates for food security include access to irrigation, climate factors, and household access to land and agriculture. Ethnic violence and the resulting insecurity and development impacts are also significant drivers of food insecurity in some areas, for example, in northern Shan State. See the FAO/WFP Agriculture and Food Security Assessment (2009) for more general information on food security.

For updates on recent conditions (including maps, statistics and conditions for specific areas), please see the following:

<http://documents.wfp.org/stellent/groups/public/documents/ena/wfp251599.pdf>

<http://documents.wfp.org/stellent/groups/public/documents/ena/wfp251435.pdf>

[http://www.fsinmyanmar.net/index.php?option=com\\_k2&view=item&layout=item&id=124&Itemid=127](http://www.fsinmyanmar.net/index.php?option=com_k2&view=item&layout=item&id=124&Itemid=127)

For < 30-page food security assessments from 2011 for the Dry Zone and Northern Rakhine, please see the following:

<http://documents.wfp.org/stellent/groups/public/documents/ena/wfp234780.pdf>

<http://documents.wfp.org/stellent/groups/public/documents/ena/wfp234781.pdf>

#### 4. AGRICULTURE AND FOOD SECURITY STATISTICS

According to a FAO (2010a) commissioned report, *Food Security Data Management Requirement Analysis and Technical Capacity Assessment*<sup>3</sup>, available socio-economic and demographic statistics, as well as agricultural and market price data, collected by various line ministries (e.g., Department of Agricultural Planning, Department of Fisheries, Department of Population), are compiled by the Ministry of National Planning and Economic Development's Central Statistical Organization (CSO) in the statistical yearbook. The statistical analytical capacity of CSO is adequate but needs further training, while other line ministries such as Department of Agricultural Planning require more extensive capacity building in database development, data analysis, data presentation, web development, and food security. Data analysis, as well as information dissemination, is hampered by a general lack of a data sharing attitude among different stakeholders.

The Myanmar off-line version of DevInfo, managed by the Myanmar Information Management Unit (MIMU), can be integrated with a food security module to store and make available the information and its metadata, directly or indirectly related to food security. Agro meteorological modelling for crop forecasting and yield prediction can be done through estimates using available satellite imagery for rainfall estimation and vegetative cover, and daily rainfall forecasts. Geographic information system (GIS) capacity is available at the Department of Geography of the University of Yangon and the department is keen to collaborate to provide mapping GIS analysis services. The mission identified a general lack of an intermediate technical level, able through data analysis, to turn data into information. This gap can be bridged by establishing a food security and nutrition analysis team able to perform improved food security analysis for linking information and decision making. All above drawn from FAO (2010a).

MIMU is a center of excellence for data management and mapping. Hosted by the United Nations Development Programme (UNDP), the MIMU provides a common information exchange service for the humanitarian and development communities through strengthened coordination, collection, processing, analysis, and dissemination of information. They also provide training and technical support for non-governmental organizations (NGOs) and other stakeholders in Myanmar to improve data collection, management, and use. This may be a good model to consider for expanded and improved agriculture data management. See <http://www.themimu.info/Baseline%20Data/>

The agriculture review from Harvard Ash Center in 2011 noted the following: "Comparing official and U.S. Department of Agriculture estimates, [we] concluded that the latter were more likely to reflect actual production levels. This conclusion has subsequently been endorsed by many parties connected with the rice trade in Myanmar". (Dapice et al. 2011). This point was based on in-country research and field studies by the Harvard team, and has been echoed by a number of other teams. However, it is also important to note, as the Harvard group does, that the United State Department of Agriculture (USDA) data can only provide a limited picture of the entire farm sector, and that there are many crops and statistics for which no alternative datasets exists (aside from those from government sources).

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<sup>3</sup> [http://www.foodsec.org/fileadmin/user\\_upload/eufao-fsi4dm/docs/Romano%20-%20Myanmar%20Food%20Security%20Data%20Management%20Requirement%20Analysis%20and%20Technical%20Capacity%20Assessment.pdf](http://www.foodsec.org/fileadmin/user_upload/eufao-fsi4dm/docs/Romano%20-%20Myanmar%20Food%20Security%20Data%20Management%20Requirement%20Analysis%20and%20Technical%20Capacity%20Assessment.pdf)

#### **4.1. Gaps/Issues to Explore**

There was mention that several agencies/groups would be separately putting data together and making it available online in the near future (noted in 2010) – the Ministry of Agriculture, DevInfo, and the Myanmar Rice Industry Association. It would be valuable to follow up with these to request any available data.

It may be helpful to understand whether any of the identified gaps/needs for data collection and management have been addressed – both to understand quality of new data and to determine whether there are opportunities to support capacity building on these issues.

It would be valuable to review the FAO (2010a) commissioned report: Food Security Data Management Requirement Analysis and Technical Capacity Assessment and seek to develop and update, as necessary, an inventory of statistical departments that collect data for agricultural and related sectors and characterize existing and needed resources, skills, and training.

## 5. AGRICULTURAL PESTS

A report by the Australian Centre for International Agricultural Research (ACIAR) from 2001 provides detailed information and tables on the distribution and importance of arthropod pests and weeds for agriculture in Myanmar. Introductory material for the report can be accessed here:

[http://aciar.gov.au/files/node/2145/the\\_distribution\\_and\\_importance\\_of\\_arthropod\\_pests\\_48147.pdf](http://aciar.gov.au/files/node/2145/the_distribution_and_importance_of_arthropod_pests_48147.pdf). The study covers ten crops or groups of crops for each of 14 agricultural regions in the country. It finds that most important overall are *Spodoptera fitum*, *Helicoverpa armigera*, *Agrotis ipsilon*, *Spilartia obliqua*, *Thrips palmi*, *Aphis gossypii*, *Odontotermes* spp, *Agrotis segetum*, *Bactrocera cucurbitae*, *Bactrocera dorsalis*, and *Sdrtothrips dorsalis*. The authors also address the possible role of Integrated Pest Management (IMP) in controlling some of these critical pests.

Studies and surveys indicate that crop pests and diseases are significant (but not dominant) constraints to crop production. For example, the LIFT Baseline Survey of 2012 reveals that around 16% of households in the study noted pests and diseases as constraints and 2% mentioned animal damage specifically (as compared to 50% mentioning lack of money for inputs and 38% noting bad weather). Note, however, that the figure was 26% for pest and disease problems in the Delta and Coastal regions.

Rodents, both rats and squirrels, are critical problems for paddy crops. A large-scale infestation occurred following Cyclone Nargis in 2008, particularly affecting food security in Chin State. Several have noted the connection between irregular climate patterns and seasonal pest incidence. Stem borer and gall midge were recently noted as dominant pests in Rakhine, according to LIFT (2012).

Pesticide use is generally not extensive, with the exception of some areas, such as east Delta near Yangon and parts of Magway. According to the LIFT Baseline Survey of 2012, around 27% of households used insecticides, though the rates were much higher (over 50%) for groundnut, potato, and chili crops. Fungicide use overall was around 10% and herbicide use around 5%. There has been a significant push for IMP and use of natural pest control, such as ducks.

### 5.1. Gaps/Issues to Explore

Reports indicated likely misuse of pesticides. Improved and more accurate pesticide use along with increased application of IMP practices could address production problems.

Further study of climate-pest relationships could help avoid future outbreaks or at least lay a foundation for increased preparedness and improved management.

## 6. CLIMATE

See Myanmar Climate Profile (Annex I) for more detailed information on historical variability and trends as well as future climate projections.

Climate variability and agro-climate regions within the country are largely shaped by topography, particularly as it affects exposure to the southwest monsoon (May-October) (RIMES 2011). There is significant spatial variability in annual rainfall, with levels as high as 5,000mm in the mountainous coastal and Delta regions, but only about 600mm in the central lowlands (Dry Zone). Temperature also varies across the country, with highs above 43 degrees Celsius (C) in Central Myanmar, around 36C in Northern Myanmar and only 29C at the eastern plateau.

The El Niño Southern Oscillation (ENSO phenomenon) affects interannual variability, with El Niño conditions frequently resulting in below normal rainfall. Impacts are felt particularly in July-September for the Dry Zone, west and some of the northwest of the country. Parts of the Dry Zone and the North have greater likelihood of being drier than normal in October-December during El Niño events (Someshwar et al., 2009).

Over the past 4-5 decades, Myanmar has experienced an upward trend in average and high temperatures and decreases in the monsoon duration. There does not appear to have been significant trends in total rainfall, though a government study suggested a slight downward trend. Some recent research suggests that pre-monsoon climate patterns have led to increases in May precipitation (thus possibly earlier monsoon onset) and increased and more intense cyclone activity since 1979. While the upward trend for temperature is clear, more research and analysis is necessary to understand rainfall and monsoon trends over the past decades. The above is drawn from Ministry of Agriculture and Irrigation (2010).

Myanmar is highly vulnerable to hydroclimate extremes, with great exposure to cyclones, a quarter of the country facing flood risk (threatening 36% of the coastal population) and many areas, particularly in the Dry Zone and into the northwest, experiencing droughts. In surveys of households in food insecure regions of Rakhine and the Dry Zone, farmers listed climate-related concerns as the main agricultural constraint (floods, landslides, and droughts, respectively) (LIFT 2012).

As noted in the LIFT Dry Zone livelihoods study (2011), micro level shocks, often very localized, are reported as equally significant as large-scale weather events. Villages in the same district separated by a few kilometer (km) can experience very different micro-climatic shocks due to localized climatic patterns.

Hydroclimate extremes are expected to become more frequent and/intense due to climate change. Average temperatures are expected to rise 1-4C by the end of the century and rainfall is project to increase around 10% (mostly concentrated in fewer rainfall days and more extreme events) (World Bank 2012).

While flow variability of the Irrawaddy and other river systems is primarily driven by summer monsoon patterns, summertime melting of the glaciers and snow levels in the northern mountains also contributes to river flow variability. Future climate projections for the Eastern Himalayan region, which includes the mountains and glaciers in Chin and Kachin states, suggest likely declines in snowfall and significant increase in snowmelt (Tse-ring et al. 2010). When higher levels of snow melt combine with more intense monsoon rainfalls, flood

disaster likelihood increases. Additionally, the expectation is that the river flow will increase in the near-to-middle term as snow and glacier melt increases, but will later decrease due to a lack of sufficient winter snowpack.

### **6.1. Gaps/Issues to Explore**

Since climate patterns are highly variable within the country, more efforts are needed to identify location-specific seasonal variability and historical trends. There is also a need to conduct downscaled climate change projections to better assess possible impacts at a sub-national level.

The Department of Meteorology and Hydrology under the Ministry of Transportation likely has much better station records than are available anywhere online – access to this data or at least existing analysis based on their data could be most valuable. It will be critical to engage with the Department to understand the characteristics of existing hydroclimatic data, such as spatial extent, length of historical record, frequency of station calibration and consistency of recording.

There does not appear to be a robust system for communicating climate (or weather) information to farmers or other possible users. However, this is not clear from the literature, so it would be helpful to get a better sense of how/whether forecasts and other information is disseminated.

## 7. SOILS

ADB/GEF/UNEP (2006) report that “official data indicate that problem soils occupy an area of about 2.4 million acres, accounting for about 5.3% of the total cultivable land area of 44.5 million acres. Of this about 0.74 million acres are acid sulphate soils, degraded soils, peat soils, and swampy soils, while saline and alkaline soils accounted for the remaining 1.63 million acres” and that “soil erosion is a key factor in making agricultural land vulnerable to land degradation – about 10% of total cultivated land in the country is estimated to be vulnerable to severe soil erosion. Severely affected areas include Shan State, Sagaing Division, and Chin State. Soil erosion in the upland regions of Myanmar is primarily a result of farming on steep lands (10 degrees or above).”

From the U.S. Army Corps of Engineers’ report on the Geology of Burma (Myanmar) (Hadden 2008):

- The lowland regions are covered with alluvial soils—mainly silt and clay. Myanmar’s richest soils are found in a narrow alluvial strip along the Bay of Bengal, where mountain streams irrigate the land in the wide Irrawaddy and Sittang river valleys. These deep soil deposits form a vast, fertile belt especially suitable for rice cultivation because of the abundant moisture.
- The Dry Zone townships are characterized by clay, sandy loam and sandy soils that include gravel. The soils clearly vary with topography. According to soil survey data, all soil series in the Dry Zone have low fertility and have declining organic matter levels. Potassium levels are also low for agriculture. Nitrogen is required for all non-legume crops on all soil types. This also suggests the consistent low organic matter level in the soil.
- The soil moisture holding capacity of the soils of the Dry Zone is low and with the high level of evapotranspiration, impacts agriculture. This lack of moisture in the ground constitutes a major constraint to crop growth during periods of inadequate rainfall, such as in June and July. Hard pan formation is common to all the upland areas.
- In the dry belt of the central region are found red-brown soils rich in calcium and magnesium.
- Soil erosion is a serious problem and in some places in the Dry Zone the soil has been almost completely removed by water and wind erosion. Soil erosion is particularly severe in the upland areas of Kyaukpadaung and Chaung U, largely as a result of the high intensity of rainfall and rapid surface runoff. Moreover, since most of the soil in these areas is moderately textured with a slope ranging from 5-15%, the erodibility of the soil is also high. In Chaung U, the most severe erosion occurs in the upland areas. In contrast, the incidence of soil erosion in the flood plain is lower. Sheet and rill erosion and vertical dissection are widespread, resulting in an uneven topography.
- In Magway, because of the sandy topsoil there is also a high level of erosion. The susceptibility of the soil to erosion is compounded by the high level of rainfall occurring over short periods. Wind erosion is a particularly severe problem, while sheet and gully erosion are largely confined to wasteland areas.
- The highland regions of Myanmar are covered with highly leached, iron-rich, dark red, and reddish brown soils. When protected by forest cover, these soils absorb the region’s heavy rain, but they erode quickly once the forest cover has been cleared.

It has been noted that in Chin State, population growth are shortening field rotation (5-7 years instead of 8-10 years), which prevents recovery of soil fertility and is reducing agricultural productivity (FAO/WFP 2009).



Myanmar's Ministry of Agriculture and Irrigation has developed a table describing the soil types, locations, cultivation constraints, and suitable crops for each of eleven agro-ecological zones in the country – [http://www.apipnm.org/swlwpnr/reports/y\\_ta/z\\_mm/mmtb231.htm](http://www.apipnm.org/swlwpnr/reports/y_ta/z_mm/mmtb231.htm)

See a 2008 FAO map of dominant soils

[http://www.fao.org/nr/myanmar/SoilMap\\_Myanmar\\_300dpi.jpg](http://www.fao.org/nr/myanmar/SoilMap_Myanmar_300dpi.jpg)

and low resolution soil maps of specific areas (e.g., Rakhine and Shan States, the Central Dry Zone, and Tanintharyi and Ayeyarwaddy Districts)

[http://www.apipnm.org/swlwpnr/reports/y\\_ta/z\\_mm/mmmp222.htm](http://www.apipnm.org/swlwpnr/reports/y_ta/z_mm/mmmp222.htm)

## **7.1. Gaps/Issues to Explore**

There is limited information on the dynamics of soil and erosion patterns, and what exists is largely based on decades old data. Establishment of monitoring stations and appropriate monitoring design could be very valuable.

The Land Use Division of the Myanmar Agriculture Service in the Ministry of Agriculture and Irrigation has produced reports on soil types and characteristics. The most recent that is available online is from 2002 and does not include the break down and maps for each state and district ([www.themimu.info/docs/Govt\\_Soil-types-description\\_Feb\\_2002.pdf](http://www.themimu.info/docs/Govt_Soil-types-description_Feb_2002.pdf)). It would be useful to work with the agency to determine whether more current or complete versions are available.

## **8. WATER RESOURCES AND IRRIGATION**

The country has abundant water resources with significant coastal access, groundwater, and five major rivers, which allow for irrigation and hydropower generation. Only about 10% of the total water resources available to the country are utilized, and 90% of that use is for irrigation (ADB 2012b).

Though water resources are significant, availability is highly variable temporally and spatially. River flows largely follow rainfall patterns, with 80% of flows during the May-October monsoon and only 20% during the November-April dry season. Seasonal water scarcity is a particular challenge in areas such as the Dry Zone and Rakhine state. While Rakhine has among the highest rainfall, water shortages outside the monsoon season are frequent due to limited natural or artificial water storage capacity.

Reservoirs collecting runoff have been developed to store sufficient water to irrigate around 1 million ha around the country as of 2005. Since 1988 the Government has made large-scale efforts in the construction of dams (for both irrigation and hydropower), reservoirs, and pump irrigation facilities throughout the country. The country has developed less than 5% of its significant hydropower potential of 40,000 mega watts. More detailed sub-national analysis of water resources and sinks would be necessary to inform decisions regarding proposed large infrastructure projects.

Total area under irrigation doubled between 1980 and 2000, and by 2004 reached about one fifth of cultivated lands (though it still accounts for less than 3% of total land area). In 2001/2, nearly 45% of all irrigated area was served by river-pumped systems; reservoir and river diversion systems accounted for 32%; private, village-based systems only around 12% of irrigated area; and groundwater production for about 5% (groundwater mainly used for domestic supplies (51.4%), with a share of 47% for irrigation and 1.6% for industrial uses) according to UNDP (2004).

UNDP (2004) notes that there is evidence that the Ayeyarwaddy delta is underlain by a series of both deep and shallow freshwater aquifers that could be developed to irrigate a large portion of land in this area, especially during the dry season.

According to FAO/WFP (2009), due to increasing demand and with support from government projects, the percentage of irrigated land increased significantly in the 1990s (from 12.6% in 1989 to 17.3% in 2002), but has remained steady at around 17% in recent years (even as net sown area increased by 25%). The Delta generally has the highest percentage of irrigated land.

While there is a mix of rainfed and irrigated monsoon paddy in different regions (Ayeyarwaddy, Yangon, and others rainfed; Dry Zone areas irrigated), all summer paddy crops in the country rely on irrigation (FAO/WFP 2009). World Food Programme (2011) identified access to irrigation as a decisive factor contributing to food security in the Dry Zone.

### **8.1. Gaps/Issues to Explore**

Status and plans for irrigation expansion – government and private efforts have largely kept pace with increases in area sown in recent years, but this continues to leave many vulnerable

populations without access with implications for food security (particularly in the Dry Zone and Rakhine).

Related point – numerous sources indicate that insufficient storage capacity (and farm level and above) lead to water scarcity, particularly for poor households and regions – there's little information on the barriers to addressing this (aside from resource constraints, but some solutions are very low tech and low cost). There is a need to determine whether there is potential for increased coordination between irrigation planning and crop selection.

The Asian Development Bank (ADB) suggests there may be increasing competition for water resources due to hydropower development.

## **9. INLAND FISHERIES AND AQUACULTURE**

Fishing is a critical part of the national economy and diet. In the early 2000s, fisheries and aquaculture provided direct employment to at least 1.3 million people in the marine sector and 1.4 million people in inland fisheries, plus an estimated 0.3 million jobs in aquaculture, so that a total of 12-15 million people benefited from this sector (UNDP 2004). Fish and shrimp have now become major exports, and the fishing sector provides two thirds of the animal proteins in the diets of the people, of which the per capita consumption of fish and fisheries products was estimated at 23 kilograms per year around 2002 (UNDP 2004). The exception is Chin State, where fish is almost nonexistent in the diet.

Total national fish production doubled in the 15 years to 2000, and may have nearly tripled over the past decade, to a level of 3.2 million tonnes (UNDP 2004 and FAO/WFP 2009). Ayeyarwaddy and Tanintharyi divisions are by far largest fish producers, each with around one third of total production (followed by Yangon, Bago, Rakhine, and Mon, largely due to more limited fishing grounds, licenses, and landing sites). As of 2002, aquaculture had been the fastest growing sector for over a decade, registering a growth rate of over 40% per year since 1988, compared with 5% for capture fisheries (Win 2004). Other statistics note an increase of 30-fold from 1991-2001 (UNDP 2004).

There is substantial fishery potential in the major rivers and considerable potential for aquaculture development in the low-lying river delta areas in the south and center of the country, and significant marine fishery resources along the country's 1,900 km coastline and 500,000 ha of mangrove swamps. Increases in small-scale village fishponds could increase household income and diet quality.

At least through 2004, government policy had restricted use of reservoirs for fisheries. A re-opening and effective exploitation of reservoir fisheries could benefit primarily poor families and could have a significant impact on national fish supplies, particularly for inland populations, according to UNDP (2004).

### **9.1. Gaps/Issues to Explore**

There have been some preliminary efforts with integrated paddy-fish operations. It may be worthwhile to explore opportunities and place, policy, or resource-based constraints.

Numerous sources note the explosion of aquaculture in recent years (in addition to overall huge growth of fisheries), but it is not clear how these are being promoted or supported (government, private sector, or individual/village initiatives).

It would be valuable to explore a full range of possible inland water sources that could be used for fisheries and aquaculture, including reservoirs.

## 10. FORESTRY

Myanmar is rich in forest resources, but has been losing around 1% of forest land per year over the past 20 years (with significant variability between states/divisions and some, such as Ayeyarwaddy, Mandalay, Yangon, and Rakhine, experiencing annual rates over 5%) (ADB/GEF/UNEP 2006). However, the closed forests status is still viewed as *reasonably sound*, accounting for over 37% of total land area (including open national lands, forests are 50% of total land) (ADB 2012b).

Climate variability across the country leads to great variety in forests. Tropical evergreen forests occur in high rainfall areas in the south of the country. Hill and temperate evergreen forests are found in the eastern, northern, and western regions at elevations over 900 m. The forest types change to deciduous and then to dry forests along a line from the edge to the middle of the country as a result of decreasing rainfall (FAO National Forest Inventory 2007). Mixed deciduous and hill/temperate evergreen make up the majority (39% and 26%, respectively).

According to FAO (2007), some 2/3 of the closed broad-leaved forest is under production. Bamboo is grown extensively throughout the country. While teak and other tree plantations exist, they are still relatively rare and cover half a million ha.

Forest degradation is greatest along the north and western areas of the Dry Zone, in the east of the country (bordering Thailand) and the southern tip of the Delta (FAO 2007). Large parts of the east and west have closed or degraded forests affected by shifting cultivation (ADP/GEF/UNEP 2006). Overall, forests affected by shifting cultivation provide resources for as many as 2 million families (UNDP 2004).

Mangroves play a key role for the coastal regions, particularly near estuaries, and are found largely along the coastal zones of Rakhine State, Taninthayi District, and the Ayeyarwady Delta. They continue to experience significant degradation – more than 50% in the Delta Forest Reserve was lost from 1924-2001, largely driven by the increase in rice cultivation (MECF 2011).

Deforestation increased significantly following economic reforms of 1988, which opened the forestry sector to private sector use. Forest loss has been positively correlated with different regions' commercial forest potential and local economy conditions. There are concerns that the growing population (particularly the poor) along with increased emphasis on forest-related trade may significantly threaten Myanmar's forestlands (ADB/GEF/UNDP 2006).

### 10.1. Gaps/Issues to Explore

As agricultural land expansion encroaches on forests, existing Community Forestry efforts and Forest User Groups may be promising ways of encouraging sustainable agroforestry practices. This resource (<http://www.burmalibrary.org/docs13/CF+Myanmar+report+-+FUG+case+studies-op75-red.pdf>) looks at a number of cases, but it may be valuable to explore possible overlap with food security efforts.

## 11. BIODIVERSITY AND ECOSYSTEMS

Myanmar has significant ecological biodiversity due to its wide range of topography across three major mountain ranges and four major river systems, and variable climate systems (critically largely tropical monsoon). Forest ecosystems support the highest levels of plant species richness, among which montane forests and lowland evergreen forests are the most species-rich. Freshwater ecosystems are found in the large, slow-flowing rivers, large lakes, and fast-flowing mountain streams, and the extensive seacoast with tidal mangroves supports marine ecosystems. Overall, eight ecosystems are recognized (forest, mountain, dry and sub-humid, estuarine mangrove, inland fresh water, grassland, marine/coastal, and small island). The above drawn from MECF (2011).

Wildlife is also diverse, including most of the larger Indo-Malayan mammals, fauna characteristics similar to Malaysian rain forests in the Tanintharyi Division, and Himalayan fauna in the mountainous area of Kachin State in the extreme north. According to MECF (2011), there are more than 25,000 species of animals, about 250 species of mammals, 400 species of reptiles, and more than 1,000 species of birds. There are also about 7,000 species of vascular plants, including over 1,600 species of climbers, 65 species of rattans, and around 850 species of orchids. Some 85 species of trees are identified as multiple-use timbers of premium quality. The country includes all or part of seven of the 200 Global eco-regions defined by the World Wildlife Fund.

The extensive coastline accommodates some half million hectares of brackish and freshwater swampland that support essential ecological functions and habitats for a range of economically valuable flora and fauna (e.g., spawning, nursery, and feeding grounds for fish and prawns). These ecosystems are experiencing significant degradation, largely do to conversion to agriculture and aquaculture and fuel wood collection. The above is drawn from the MECF (2011).

Recognizing the great value of plant genetic resources and increasing threats to these resources, the Ministry of Agriculture and Irrigation has established a Seed Bank with over 10,000 accessions of important crops (e.g., rice – the dominant crop, cereals, legumes, and oil seed crops).

The Ministry of Environmental Conservation and Forestry is responsible for biodiversity and wildlife conservation. It produced a National Biodiversity Strategy and Action Plan (MECF 2011) <http://www.cbd.int/doc/world/mm/mm-nbsap-01-en.pdf>. This report includes useful information on biodiversity conditions, including for agriculture applications. Overall, the government had designated over 7% of total area in the country as Protect Areas and sanctuaries by 2008.

The MECF (2011) includes a brief review of three different characterizations of the agroecological zones in the country: one combined five major soil zones with three rainfall regimes to identify 15 agro-climate zones; another identified eight zones using differences in monthly meteorological data across 34 sites; and the FAO isolated six agro-climate zones (Bago-Kachin Riverside Land; Central Dry Zone; Delta and Coastal Lowland; Kachin and Coastal Upland; North, East and West Hills; Upper, Lower Myanmar, and Shan Plain).

According to the MECF (2011), species diversity of coastal and marine ecosystems in Myanmar remains largely unknown and has yet to be thoroughly explored.

Agricultural expansion and shifting cultivation are noted as partial causes of habitat degradation and biodiversity loss. Some studies have suggested positive ecosystem benefits of shifting cultivation; intense shifting cultivation in northern Chin State and northern Sagaing are connected with high rates of net forest loss while high population growth leading to farming on marginal lands in southern Chin State has also been implicated in high deforestation and land degradation. There are also significant concerns about conversion of biodiversity rich lands into plantations (e.g., for teak in central areas and for oil palm in lowland forests of Taninthayi), according to the MECF (2011).

### **11.1. Gaps/Issues to Explore**

As noted in the NBSAP, comprehensive surveys and inventories of plants, animals, and microorganisms related to agricultural production, their conservation, and utilization in Myanmar are needed.

There is also a great need to explore connections between agriculture practices (e.g., shifting cultivation) and biodiversity dynamics, and to seek opportunities to harmonize agriculture activities with conservation and habitat preservation priorities.

## APPENDIX I: MYANMAR CLIMATE PROFILE<sup>4</sup>

**Table A1. Agro-climatic Zones of Myanmar**

Name	Geographical description	Administrative units	Main agricultural practices
A. Bago, Kachin River-side Land	Upper Delta, Kachin plain, flat plain along the side of river Ayeyarwady and Sittaung, moderate rainfall (1000 - 2500 mm)	Ayeyarwady Division, Kachin State, Sagaing Division, Mandalay Division, and Bago Division	Rice, pulses, oilseeds, sugarcane, tobacco and Kaing/Kyun cultivation
B. Central Dry Zone	Central dry zone, rainfall less than 1000 mm, highest temperature in summer, flat plain, some areas with uneven topography	Magwe Division, Mandalay Division, and Sagaing Division	Upland crops, oilseeds, pulses, rice, cotton, irrigated agriculture and Kaing/ Kyun cultivation
C. Delta and Coastal Lowland	Delta, lowland and mouth of rivers in coastal area, heavy rainfall (more than 2500 mm)	Ayeyarwady Division, Yangon Division, Bago Division, Mon State, Kahyin State, Tanintharyi Division and Rakhine State	Rice, pulses, oilseeds and nipa palm
D. Kachin and Coastal Upland	Mountainous, slope land, heavy rainfall (more than 2500 mm)	Kachin State, Rakhine State, Tanintharyi Division, Mon State, Kayin State, Kayah State, Yangon Division, and Bago Division	Orchard, plantation crops, fruit trees and upland agriculture
E. North, East and West Hills	Hilly areas, uneven topography, moderate to heavy rainfall, slope land	Kachin State, Chin State, and Shan State	Upland crops, shifting cultivation and fruit trees
F. Upper, Lower Myanmar and Shan Plain	Plain, upper and lower parts outside of central dry zone, plateau	Sagaing Division, Kachin State, Shan State, Bago Division, Magwe Division, Mandalay Division, and Yangon Division	Upland crops, oilseeds, pulses, vegetable and wheat

Source: MAS.

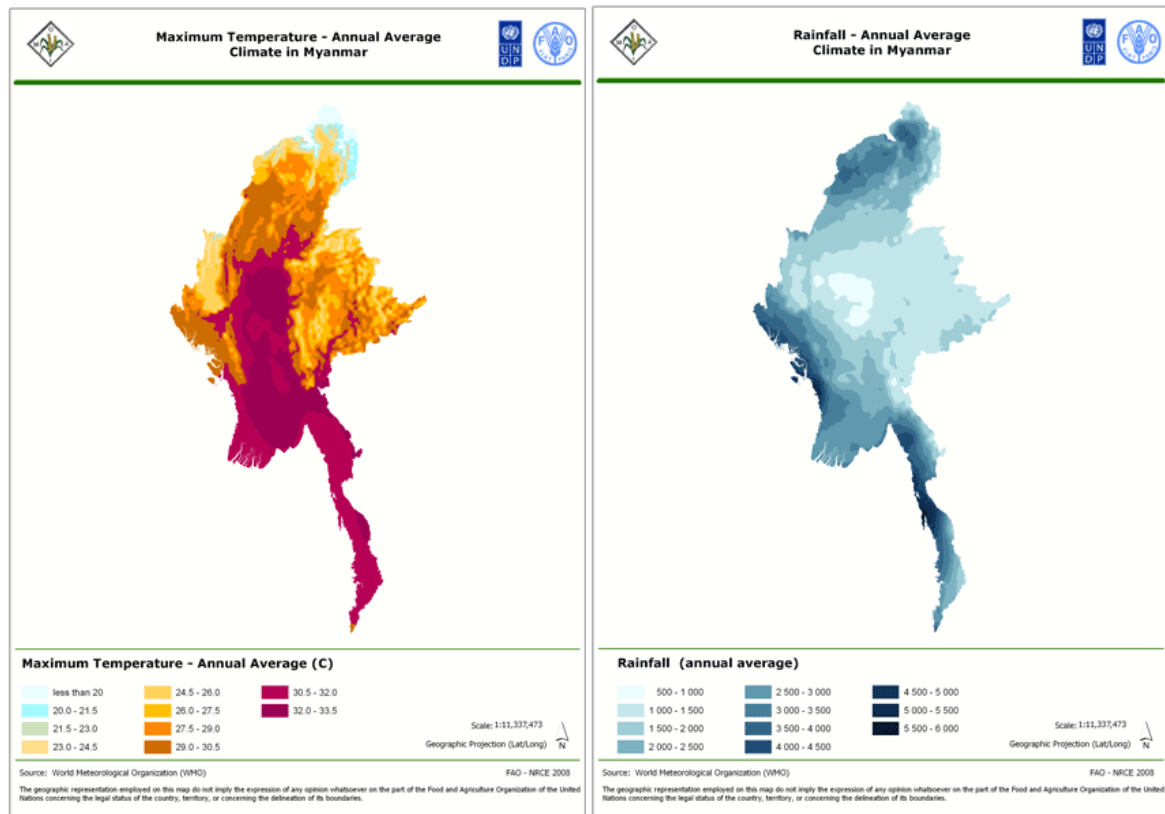
### A1.1. Climate Background

Myanmar has a dominant tropical monsoon climate. Seasons can generally be broken down as a cooler dry season from November to April and a hotter rainy season from May through October driven by the rainy southwest monsoon. The southern parts of the country are affected first by the southwest monsoon starting in May, with the entire country experiencing the rainy season by the beginning of June. Climate variability and agro-climate regions within the country are largely shaped by topography, particularly as it affects exposure to the southwest monsoon. There is significant spatial variability in annual rainfall, with levels as high as 5,000mm in the mountainous coastal and Delta regions, but only approximately 600mm in the central lowlands (Dry Zone). Temperature also varies across the country, with highs above 43C in Central Myanmar, ~36C in Northern Myanmar and only 29C at the eastern plateau (RIMES 2011).

<sup>4</sup> For use in bio-physical characterization of Myanmar for agriculture and food security. Developed by Kye Baroang, Center on Globalization and Sustainable Development, Earth Institute at Columbia University for USAID's Improving Food Security Research and Analysis Capacity (GDG-A-02-000921-00), led by Michigan State University. October 2012.

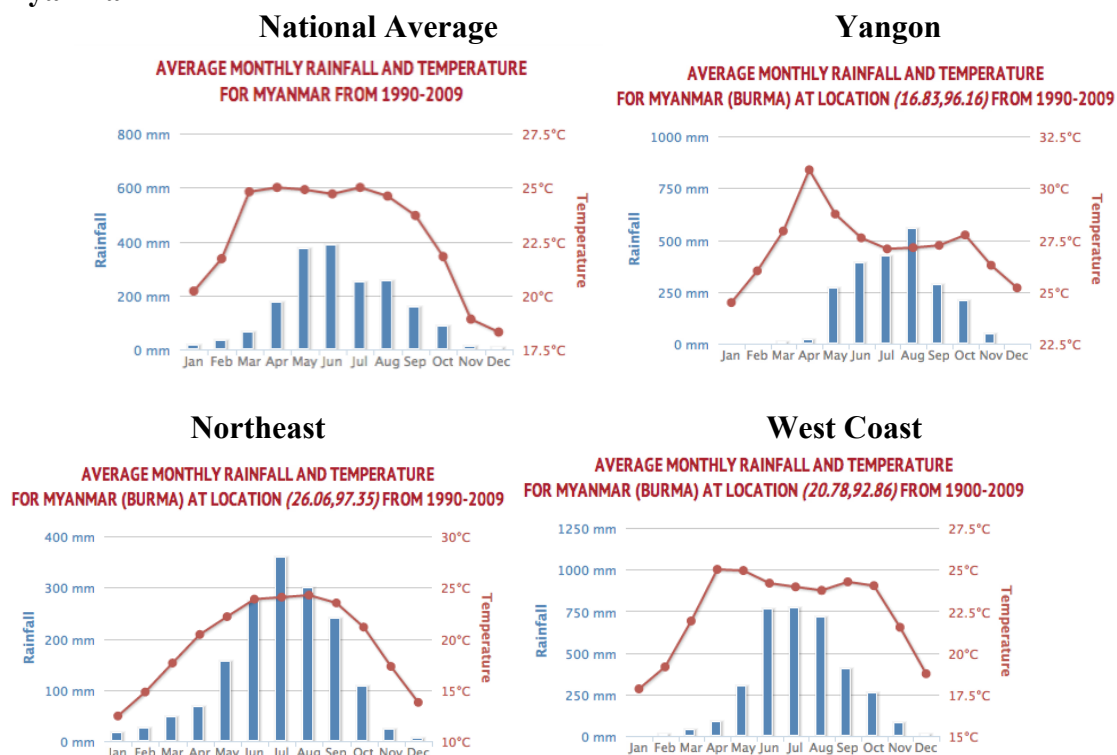


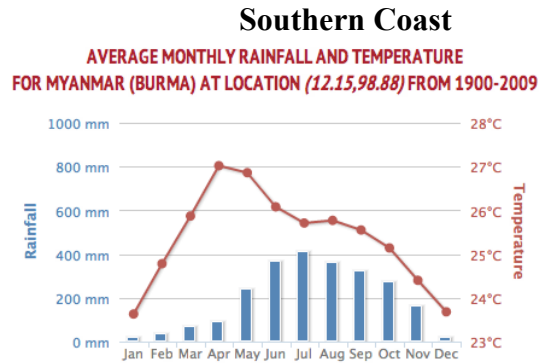
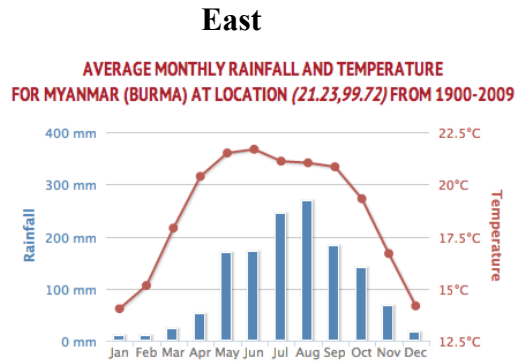
**Figure A1. Map of Average Annual Average Maximum Temperatures and Rainfall Totals**



Source: FAO 2009.

**Figure A2. Average Monthly Rainfall and Temperatures for Different Regions of Myanmar**



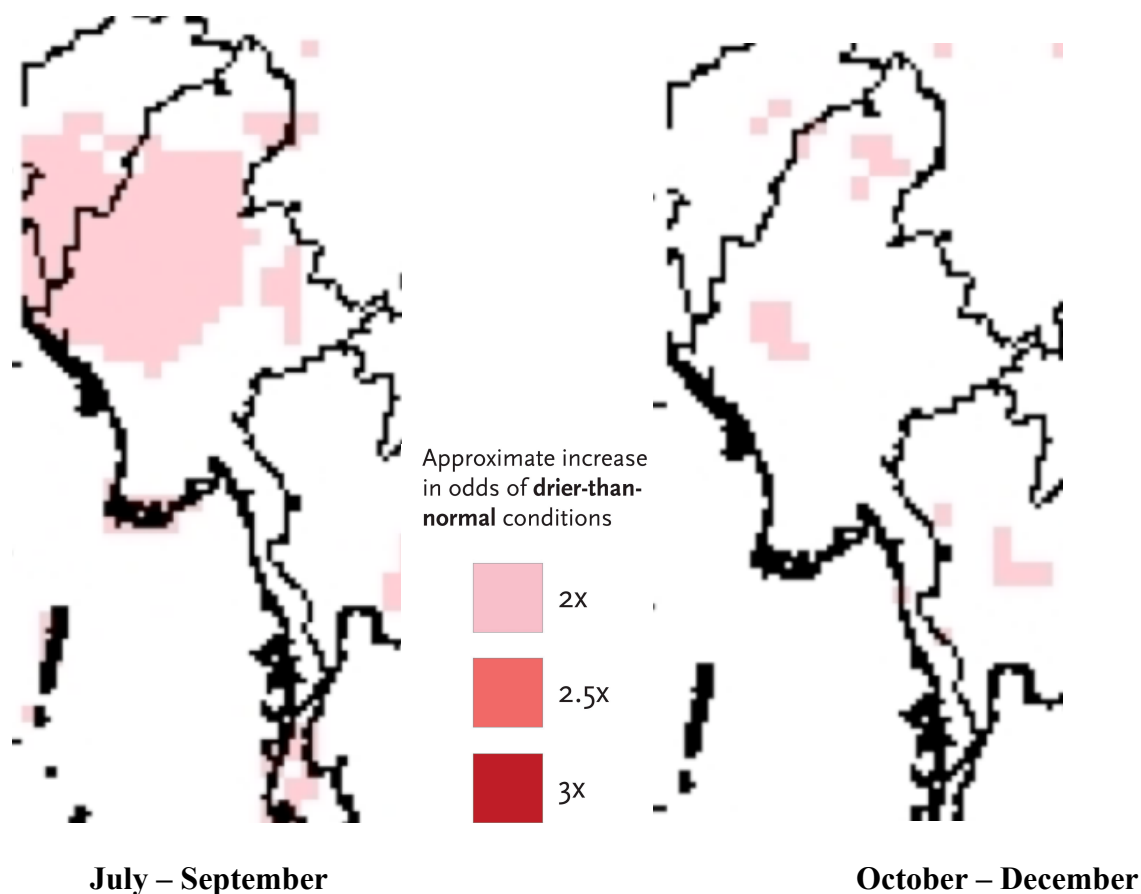


Source: World Bank 2012 (Dataset produced by the Climatic Research Unit of the University of East Anglia).

## A1.2. Historical Variability, Trends, and Extreme Events

Interannual rainfall and temperature variability in Myanmar (particularly in the summer monsoon months) is affected by the ENSO phenomenon as well as the Pacific Decadal Oscillation (PDO). Based on over 50 years of data, Sen Roy and Sen Roy (2011) found a negative relationship between ENSO and precipitation (i.e., positive El Niño conditions lead to decreased rainfall), mediated or accentuated by PDO phase, but with cold PDO episodes generally linked to higher annual precipitation. Importantly, there were substantial regional variations in the strength of these relationships. The maps below reveal the relationship between El Niño conditions and below normal rainfall. For example, the light pink color indicates that a specific area is twice as likely to have below normal precipitation for a particular three-month period under El Niño conditions, compared to a normal year. Note that the colors do not represent the intensity of dryness. Maps show only results with a 90% statistical significance, highlighting regions that are most routinely impacted during El Niño conditions.

**Figure A3. Map Showing Increased Odds of Dry Conditions in Myanmar Due to El Niño Conditions**



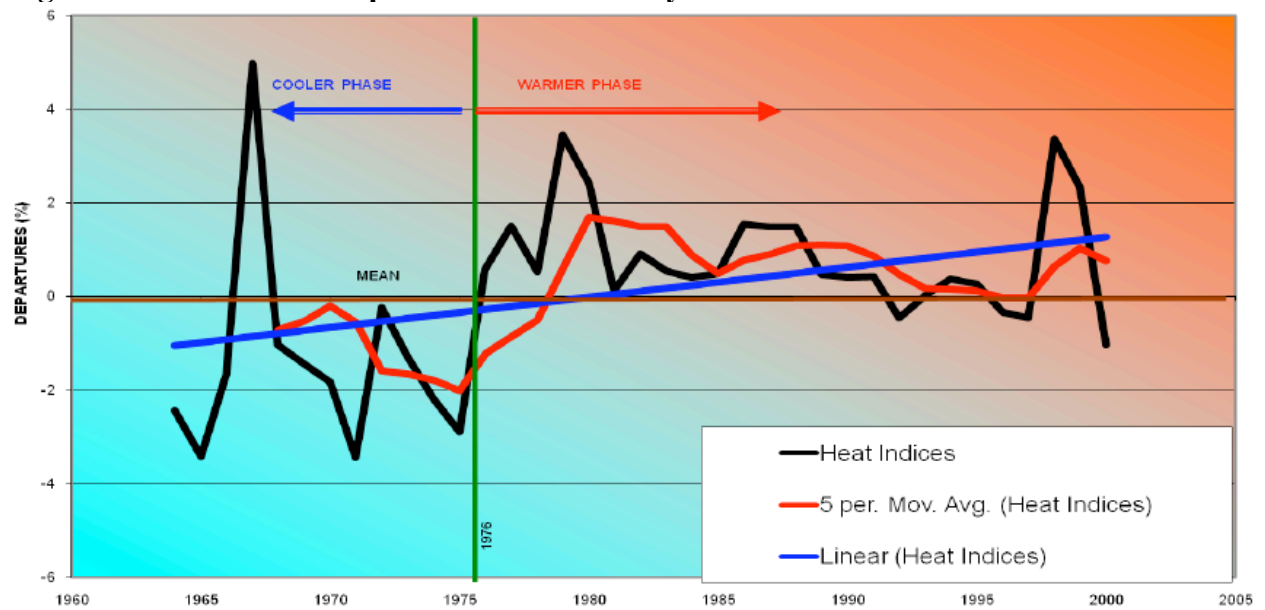
Source: Someshwar et al. 2009.

A study using analysis of teak tree rings in Myanmar has confirmed the tendency for El Niño warm events to be linked with low rainfall and drought conditions over the country and southeast Asian region (D’Arrigo et al. 2011). The tree ring analysis, which provides a record spanning three centuries, suggests a relationship between local climate conditions in Myanmar and the regional to large-scale events elsewhere (e.g., mega droughts in Thailand and Vietnam). The results also indicate a weaker than expected relationship with Indian Ocean climate indices, such as the Indian Ocean Dipole Mode.

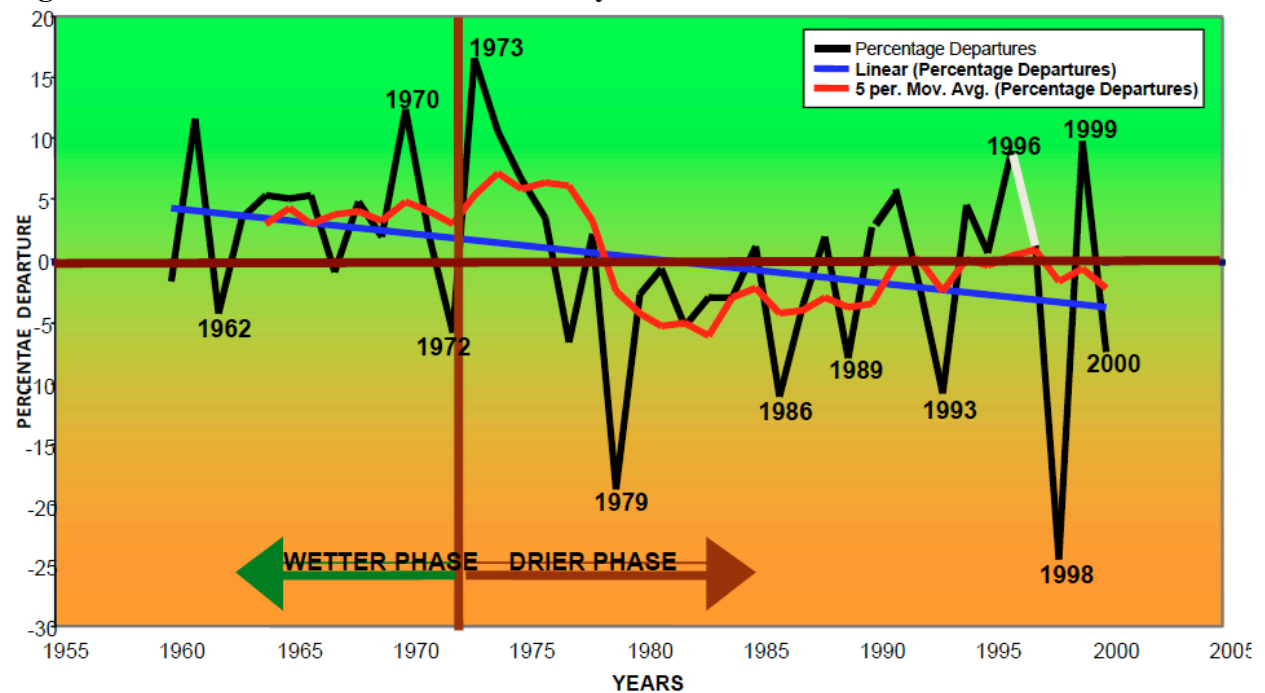
#### *A1.2.1. Trends*

Based on statistics from the Department of Meteorology and Hydrology for 1960 - 2000, Myanmar has experienced a significant upward trend in temperatures and a downward trend in rainfall (Ministry of Agriculture and Irrigation 2010). The same analysis for 1955 – 2008 suggests a strong decrease in monsoon duration (around 0.5 days per year, on average). See below figures.

**Figure A4. Historical Temperature Trends in Myanmar**

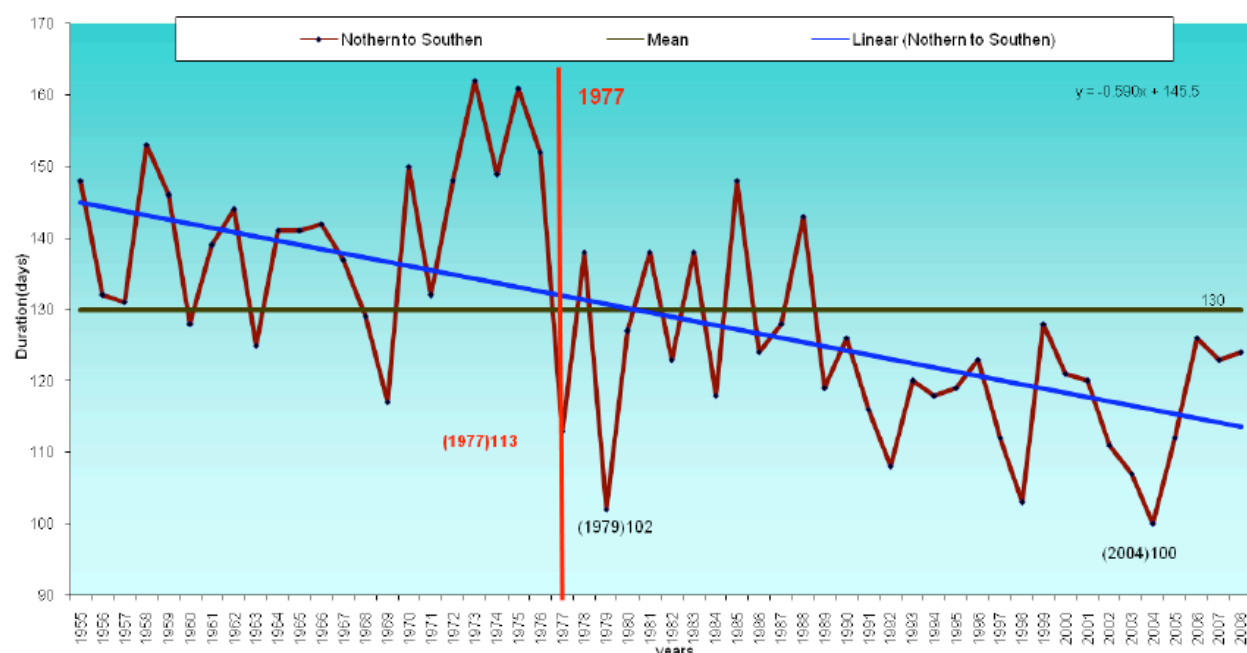


**Figure A5. Historical Rainfall Trends in Myanmar**



**Figure A6. Historical Monsoon Trends in Myanmar**

Duration of Monsoon since Onset in Northern till Withdrawal from Southern Myanmar Areas(1955-2008)



Source: Ministry of Agriculture and Irrigation 2010.

However, other studies have suggested that there is conflicting information regarding trends for rainfall totals or extremes, and that there may have been no significant trends over recent decades (RIMES 2011). Additionally, an upcoming paper suggests that pre-monsoon climate patterns have led to increases in May precipitation (thus possibly earlier monsoon onset) and increased and more intense cyclone activity since 1979 (Wang et al. forthcoming). While the upward trend for temperature is clear, more research and analysis is necessary to understand rainfall and monsoon trends over the past decades.

#### *A1.2.2. Extreme Events*

Myanmar has very high exposure and vulnerability to hydroclimate extremes. The tables below illustrate the significant human and financial losses and impacts associated with storms and major flood events. Approximately 24% of coastal land and 23% of inland areas face flood risk, affecting some 36% and 19% of the population in the respective areas (ADB 2012a). Though they are not represented below and there are few statistics or maps on prevalence, drought events are a main driver of food insecurity, particularly for the Dry Zone and the region extending into the Northwest.

**Table A2. History of Significant Cyclones in the Delta and Coastal Areas (1968-2008)**

No	Name	Date	Peak Surge(m)	Land fall point	Death toll	Losses estimated (kyats)
1	Sittwe Cyclone	7.5.1968	4.25	Near Sittwe	1037	800million
2	Pathein Cyclone	7.5.1975	3.00	Near Pathein	304	776 million
3	Gwa Cyclone	4.5.1982	3.70	Near Gwa	31	38 million
4	Maungdaw Cyclone	2.5.1994	3.66	Near Maungdaw	10	78 million
5	Mala Cyclone	29.4.2006	4.57	Near Gwa/Yangon	37	1264 million
6	Akash Cyclone	14.5.2007	-	Rakhine State	14	589 million
7	Nargis Cyclone	2.5.2008 to 3.5.2008	7.02	Ayeyarwady/ Mon Yangon	138000	11 Trillion

Source: Zaw 2010.

**Table A3. Major Hydroclimate-related Disasters from 1982 – June 2011**

Disaster	Date	No. Total Affected
Storm	2-May-2008	2,420,000
Flood	15-Jul-1974	1,400,000
Storm	23-Oct-1965	500,000
Flood	13-Jul-1991	359,976
Storm	22-Oct-2010	260,049
Flood	Jun-1976	200,000
Storm	21-Apr-1936	150,000
Mass Movement Wet	17-Jun-2010	145,000
Flood	21-Aug-1997	137,418
Storm	17-May-1978	132,000

Source: RIMES 2011.

**Table A4. Storm Distribution throughout the Year (1887 – 2007)**

Month	Storms formed in the Bay of Bengal	Storms which crossed Myanmar coast
JAN	16 (1%)	2 (2%)
FEB	3 (0%)	1 (1%)
MAR	8 (1%)	---
APR	32 (3%)	15 (19%)
MAY	89 (7%)	24 (30%)
JUN	111 (9%)	1 (1%)
JUL	180 (15%)	---
AUG	192 (15%)	---
SEP	209 (17%)	---
OCT	190 (15%)	14 (18%)
NOV	141 (11%)	14 (18%)
DEC	77 (6%)	9 (11%)
Total	1248 (100%)	80 (100%)

APRIL-MAY IS FIRST STORM PERIOD FOR MYANMAR WITH POSSIBILITY OF 49% CHANCE OF LAND CROSSING.

OCT-NOV-DEC IS SECOND STORM PERIOD FOR MYANMAR WITH POSSIBILITY OF 47% CHANCE OF LAND CROSSING.

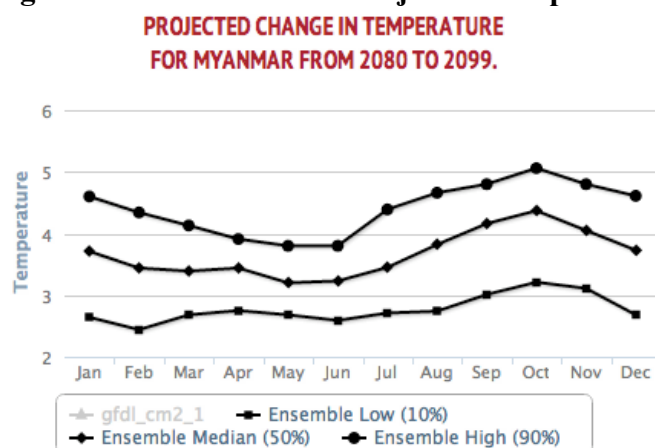
Source: Ministry of Agriculture and Irrigation 2010.

### A1.3. Projections of Future Climate Change

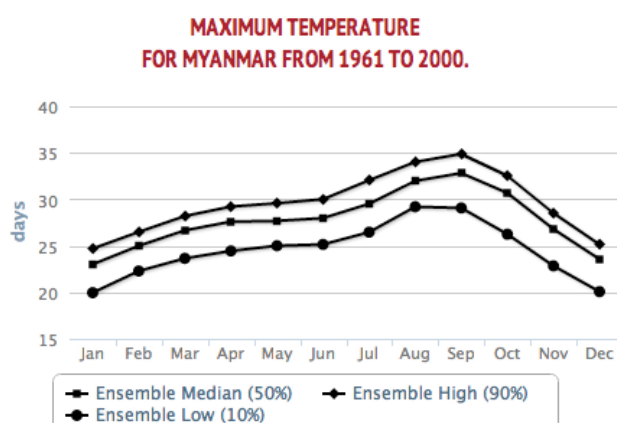
Climate change is expected to have a considerable impact on Myanmar, particularly as a result of increasing temperatures, more variable rainfall, the possibility of more intense extreme climate events, and sea level rise along the coasts. Myanmar is one of the most vulnerable countries globally in terms of projected changes in extreme weather, agricultural productivity loss, sea level rise, and overall risk (Wheeler 2011).

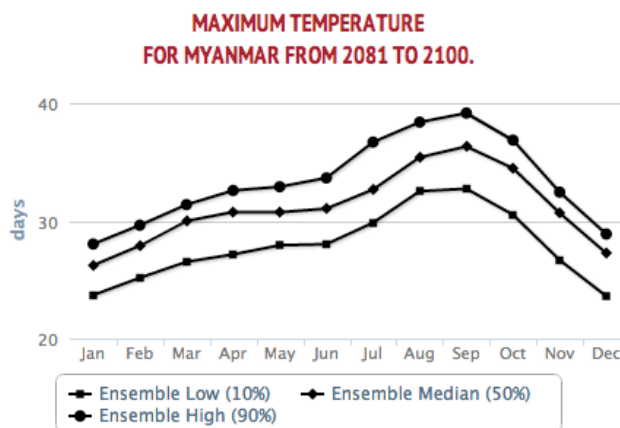
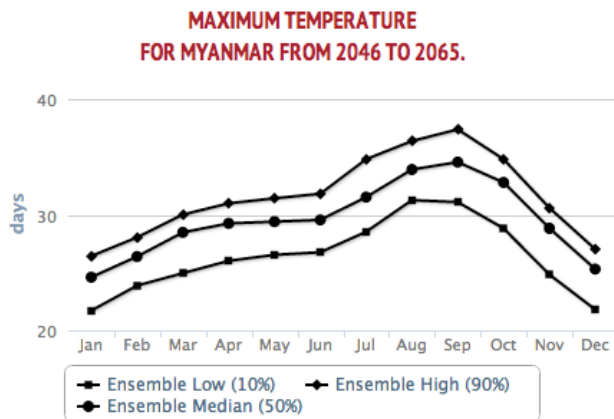
Multiple studies downscaled to the regional and national level indicate that Myanmar is projected to experience a mean annual temperature increase of between 1-4C by the end of the century, with variability throughout the year and spatially across the country (see RIMES 2011 and World Bank 2012). This will affect average annual maximum temperatures, as well. See figures below.

**Figure A7. Historical and Projected Temperatures for Myanmar**



Source: World Bank 2012.



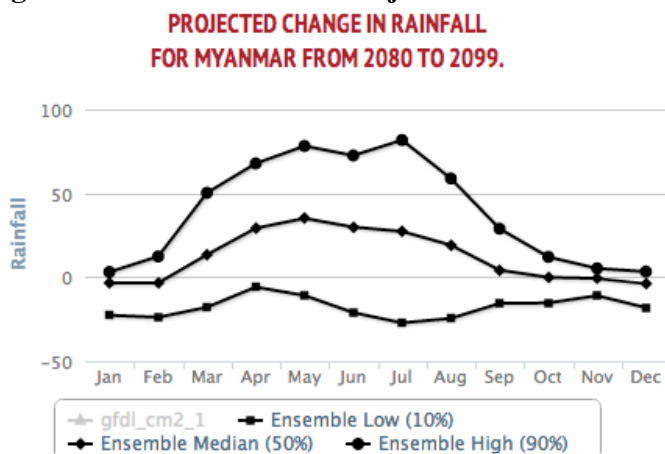


Source: World Bank 2012.

The same studies noted above also suggest projections of increasing average rainfall of around 10% for Myanmar over the coming decades, particularly in the wet season and likely concentrated into greater intensity flood events (see RIMES 2011 and World Bank 2012).

The figures below illustrate the range and/or average of multiple climate model projections.

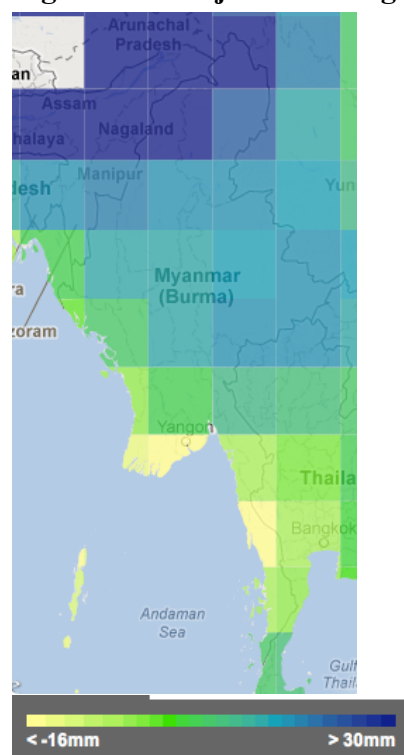
**Figure A8. Historical and Projected Rainfall Totals for Myanmar**



Source: World Bank 2012.

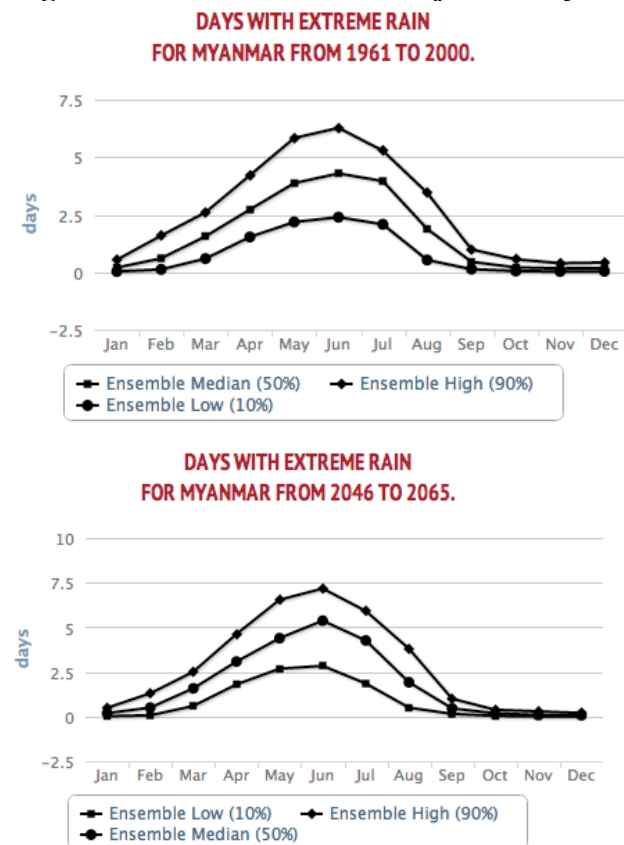


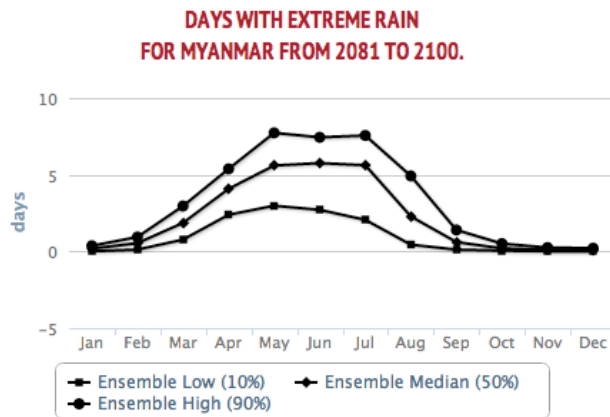
**Figure A9. Projected Change in Rainfall for Myanmar for 2080 to 2099**



Source: World Bank 2012.

**Figure A10. Historical and Projected Days with Extreme Rain in Myanmar**



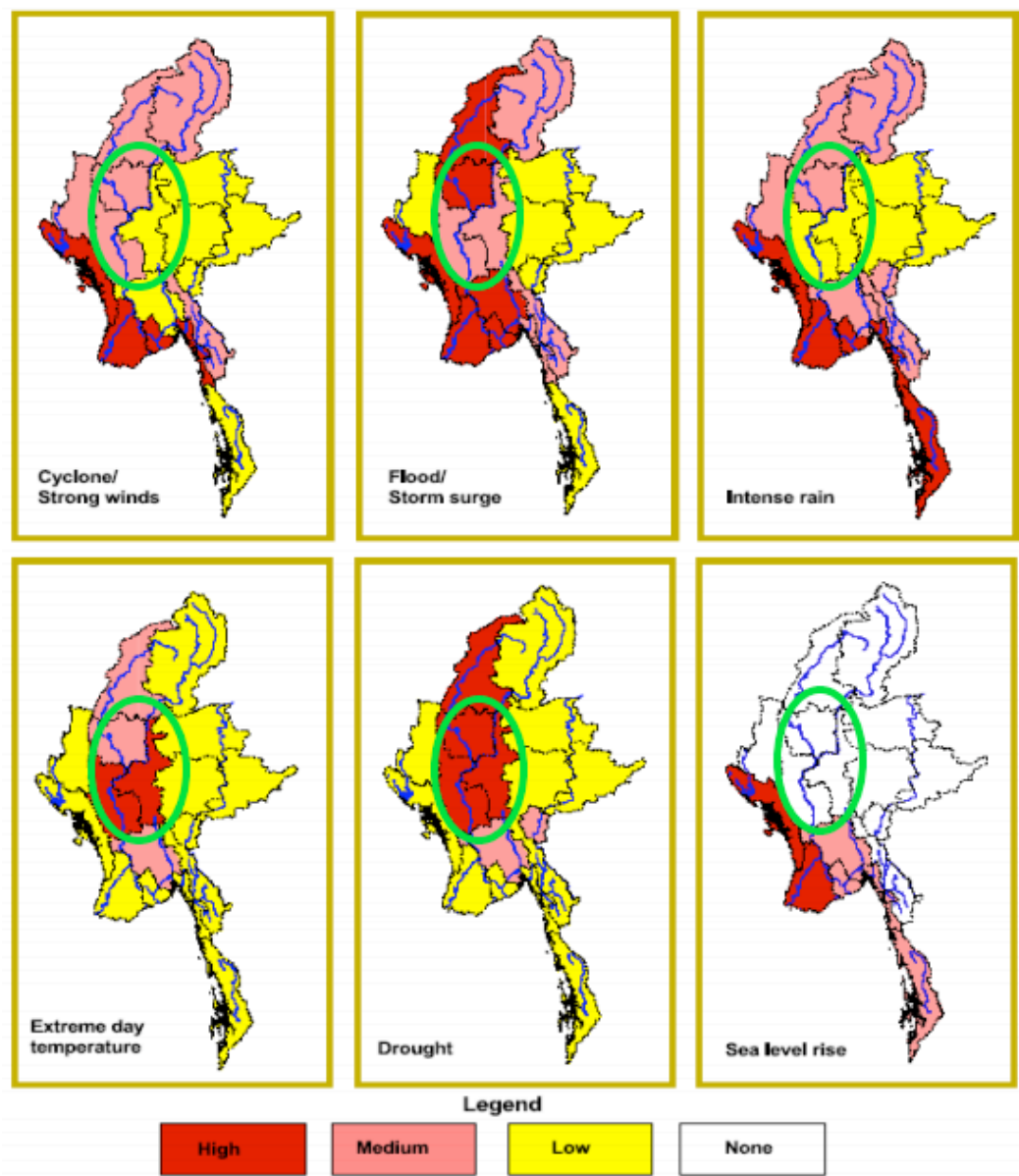


Source: World Bank 2012.

There may also be important impacts on the glaciers and snow levels in the northern mountains, the summertime melting of which contributes to flows in the Irrawaddy River and other river systems in the country (note, however, that river flow variability is primarily driven by summer monsoon patterns). Projections for the Eastern Himalayan region, which includes the mountains and glaciers in Chin and Kachin states, suggest likely declines in snowfall and significant increase in snowmelt (Tse-ring et al. 2010). When higher levels of snow melt combine with more intense monsoon rainfalls, flood disaster likelihood increases. The expectation is that the river flow will increase in the near-to-middle term as snow and glacier melt increases, but will later decrease due to a lack of sufficient winter snowpack.

As presented in the UNDP's proposal for funding from the Adaptation Fund, the Department of Meteorology and Hydrology developed a series of maps indicating the spatial distribution of projected climate change-related risks for the country (UNDP 2011). The maps are based on extrapolation of observed time-series data and confirmed by global climate models. The area encircled in green is the Dry Zone. Each of these elevated risks can be expected to impact agriculture and food security, though there is currently limited data and capacity to quantifiably model those expected outcomes.

Figure A11. Distribution of Projected Climate Change-related Disaster Risks



Source: UNDP 2011.

## **APPENDIX II: MYANMAR BIO-PHYSICAL CHARACTERIZATION ANNOTATED BIBLIOGRAPHY<sup>5</sup>**

The resources provided below are of value for those researching or assessing food security and the agriculture sector in Myanmar. The focus is on resources relevant for a bio-physical characterization of the country. As such, there is less emphasis on resources primarily addressing socioeconomic, policy and institutional aspects of agriculture and food security. This report is separated into two sections: the first part includes reports, data and map collections and resources specific to Myanmar, while the second section provides mostly data and map resources at the global or regional scale.

The resources specifically addressing Myanmar generally fall into one of three categories. The first category comprises reports assessing and/or evaluating Myanmar's agriculture or related sectors or sub-sectors (e.g., forestry, food security, and nutrition). These are typically generated by donors and include the ADB agriculture and natural resources assessment (2012b), the Harvard Kennedy Center's evaluation of agriculture policy and trends (Dapice et al. 2011), the EC-FAO report on climate change and food security (2011), the FAO-WFP crop and food security assessment mission (2009), the FAO national forestry inventory (2007), the LIFT baseline survey and evaluation reports (2012), the FAO food security data management and capacity assessment (2010a), and the UNDP agriculture sector review and strategy document (2004), among others. These reports provide analysis of the context in Myanmar, often also offering recommendations for policy or programming activities.

The second category of resources includes data sets, map collections, and data-heavy profiles. Some useful examples in this category include results from the FAO Agriculture Census (2003), the FAO Myanmar Digital Agriculture Atlas (2009), the FAO-hosted food security indicators (2010b), the FAO (2012) fishery and agriculture profiles, the maps on climate and disasters from ITHACA Web (2012), the soil type and characteristics from the Ministry of Agriculture and Irrigation (2002), and maps on population, landscape, climate, environmental performance, and others from the National Aeronautics and Space Administration (NASA) Socioeconomic Data and Applications Center. While there are discrepancies in the data shown in some resources, it is valuable to have access to available sources in order to understand and address gaps and inconsistencies.

There are a small number of resources that fall into the third category of case studies and academic/research papers. These include case studies on community forestry (Springate-Baginski et al., 2011), a report on land use that includes a case study for Southern Shan State (Egashira and Than 2006), a paper on increasing rice cropping intensity (Naing, Thein, Finckh and Buerkert 2002), as well as the United States Government's annotated bibliography of Myanmar's geology, geography and earth science (Hadden 2008). It is worth noting that while the research papers/case studies collected in this bibliography is clearly only a sample of such papers, there are actually rather few existing resources that fall into this category.

The resources in the second section of this bibliography are primarily data sets and map collections that cover the globe or, less often, the Asia-Pacific region. They have been offered in this report because a user can identify (or refine search or viewing tools to gain access to)

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<sup>5</sup> For use in bio-physical characterization of Myanmar for agriculture and food security. Developed by Kye Baroang, Center on Globalization and Sustainable Development, Earth Institute at Columbia University for USAID's Improving Food Security Research and Analysis Capacity (GDG-A-02-000921-00), led by Michigan State University, November 2012.

information or visualizations specific to Myanmar. This includes general agricultural data (FAO, USDA), specific crop data (International Rice Research Institute (IRRI), soil information (International Soil Reference and Information Center (ISRIC), International Institute for Applied Systems Analysis (IIASA) and FAO, climate (International Research Institute for Climate and Society (IRI) and others), hazards (Hazard Early Warning System (HEWS), food security indicators (FAO), and socioeconomic data (World Bank).

## **A2.1. Resources Focusing on Myanmar**

Asian Development Bank, Global Environment Facility (GEF) and United Nations Environment Programme. 2006. National Performance Assessment and Subregional Strategic Environment Framework in the Greater Mekong Subregion. Myanmar National Environmental Performance Assessment (EPA) Report. Prepared by the National Commission for Environmental Affairs, Myanmar and Project Secretariat UNEP Regional Resource Center For Asia and the Pacific. Accessed on 21 October 2012 from <http://www.ekh.unep.org/files/SEF%20II%20Report%20-%20Myanmar.pdf>

This document by the ADB, GEF, and UNEP is the National Environmental Performance Assessment for Myanmar. It provides an overview of the environmental sector in the introductory section. It also includes an assessment of performance under principal environmental concerns, and the factors that affect performance. It concludes by providing recommendations that are vital for planning and improvement of environmental management in Myanmar. Some of the topics include forest resources, biodiversity, land degradation, water resources, solid waste management, air pollution, and climate change.

Asian Development Bank. 2012. Sector Assessment (Summary: Agriculture and Natural Resources). Interim Country Partnership Strategy: Myanmar, 2012-2014. Accessed on 10 October 2012 from <http://www.adb.org/sites/default/files/mya-interim-2012-2014-ssa-01.pdf>

This valuable document contains the sector summary for agriculture and natural resources within the larger strategy report on the interim country partnership between ADB and Myanmar. It provides an overview on the sector performance, including problems and opportunities, trends, constraints, institutional performance and governance, and development needs. It briefly reviews the government strategy and ADB's sector experience.

Dapice, David O., Thomas J. Vallely, Ben Wilkinson, and Malcolm McPherson. 2011. Myanmar Agriculture in 2011: Old Problems and New Challenges. Harvard Kennedy School's Ash Center for Democratic Governance and Innovation. Accessed on 9 October 2012 from <http://www.ash.harvard.edu/extension/ash/docs/myanmar1111.pdf>

This valuable paper discusses problems and challenges for agriculture in Myanmar. It begins by setting the background and includes major developments and findings. It discusses the 2009-2010 housing living conditions survey, production trends, and other agricultural issues in the country. The primary focus is on financial issues, such as exchange rates, agriculture prices, indebtedness, as well as domestic agricultural policy.

Egashira, Kazuhiko and Aye Aye Than. 2006. Land Use in Myanmar with a Case Study in Southern Shan State. *Journal of the Faculty of Agriculture Kyushu University* 51.2: 383-387. Accessed abstract on 27 November 2012 from <http://agris.fao.org/agris-search/search/display.do?f=2007%2FJP%2FJP0705.xml%3BJP2007002536>

The study looks at general aspects of land use in Myanmar based on FAO data. It focuses on a case study of the Southern Shan State, which is a hilly region. It identifies the major land uses, which are upland fields and paddy fields and discusses characteristics of individual land use types. Statistics include area harvested of some crops in Myanmar as well as area and rate of increase over time for Myanmar and Southern Shan State. It also provides a characterization of land use for paddy, upland fields, fields on river sediment, gardens, and rubber plantations.

European Commission and the Food and Agriculture Organization of the United Nations. 2011. Managing Climate Change Risks for Food Security in Myanmar. Accessed on 27 November 2012 from [http://www.foodsec.org/fileadmin/user\\_upload/eufao-fsi4dm/docs/Myanamr%20-%20RIMES%20\(2011-07\)%20Managing%20Climate%20Change%20Risks%20for%20Food%20Security.pdf](http://www.foodsec.org/fileadmin/user_upload/eufao-fsi4dm/docs/Myanamr%20-%20RIMES%20(2011-07)%20Managing%20Climate%20Change%20Risks%20for%20Food%20Security.pdf)

This report focuses on managing climate change risks with regard to food security in Myanmar. The technical report is brief but covers a range of topics with critically valuable climate-related data and information. In exploring food security and climate, it examines climate trends (historical trends, extreme events, projected climate change scenarios, and gaps and assessment of needs). It also covers information relevant to decision making, such as climate-sensitive sectors connected to food security, decision making frameworks and policies, institutional structures, gaps in information, and priorities in information for food security.

Food and Agricultural Organization of the United Nations and World Food Programme. 2009. Special Report – Crop and Food Security Assessment Mission to Myanmar. Accessed on 20 October 2012 from <http://documents.wfp.org/stellent/groups/public/documents/ena/wfp196368.pdf>

This very valuable report offers the findings from a joint FAO/WFP mission to Myanmar to assess the crop and food security situation following Cyclone Nargis. The report includes a useful overview of agriculture in Myanmar, including statistics and information on socio-economic conditions, agricultural land use, irrigation facilities, net area sown for a wide variety of crops, fertilizer use, and various aspects of government policy. Following the general overview, the report provides extensive data on crop production, food security, and cyclone losses for 2008. The authors then offer projections for agriculture yields and price outlook for 2009. There is some information on household food insecurity and vulnerability.

Food and Agriculture Organization of the United Nations. 2001. Improvement of Agricultural Statistics in Asia And Pacific Countries (GCP/RAS/171/JPN) – Proceedings of the National Seminar on the System of Food and Agriculture Statistics in Myanmar. Accessed on 27 November 2012 from [http://faorap-apcas.org/myanmar/No.2\\_MYN\\_2\\_1.pdf](http://faorap-apcas.org/myanmar/No.2_MYN_2_1.pdf)

This document contains papers from a 2001 national seminar. The papers cover various aspects of agriculture and food statistics, authored by officials from the Myanmar government. Key papers cover topics such as statistical activities relating to food and agricultural systems, livestock, fisheries, forestry, agricultural census, and national accounts and gross domestic products on agriculture. The papers are comprehensive and include background information, statistics, and detailed information on data management and use.

Food and Agriculture Organization of the United Nations. 2003. Myanmar Agricultural Census 2003 – Main Results. Accessed on 8 October 2012 from [http://www.fao.org/fileadmin/templates/ess/documents/world\\_census\\_of\\_agriculture/main\\_results\\_by\\_country/Myanmar\\_2003F.pdf](http://www.fao.org/fileadmin/templates/ess/documents/world_census_of_agriculture/main_results_by_country/Myanmar_2003F.pdf)

This document contains the main results of the 2003 census on agriculture carried out in Myanmar. It includes statistics and data tables on information relating to agricultural holdings, area, legal status, land use, irrigation, livestock, crop types, farming systems, and fertilizers/pesticides. It also includes explanatory notes giving brief information on how the census was conducted and presented, including details on sources, methods, and definitions.

Food and Agriculture Organization of the United Nations. 2005. Regional Data Exchange System (RDES) with CountrySTAT – Asia and the Pacific. Land Use of Myanmar. Accessed on 21 October 2012 from <http://faorap-apcas.org/rdes/px/Dialog/varval.asp?ma=MR-A01-A0-LandUse&ti=Land+use+of+Myanmar&path=../Database/FAO/1%20Country%20Data/9%20Myanmar/&lang=1>

This webpage includes a searchable database on information related to the land use of Myanmar. The years for which data is available are from 1993-2003. Information includes total land, land area, crop land, irrigated area, and cultivated area.

Food and Agriculture Organization of the United Nations. 2006. Fishery and Aquaculture Profile: The Union of Myanmar. Accessed on 10 October 2012 from <http://www.fao.org/fi/oldsite/FCP/en/MMR/profile.htm>

This website provides a country profile of the fisheries and aquaculture of Myanmar. The overview includes information such as general economic data, commodity balance, estimated employment, trade, details on capture fishery, inland fishery, aquaculture, and the management of these sectors. It also looks at the policies and the development of the fishery sector, legal framework, research, aid, and institutions.

Food and Agriculture Organization of the United Nations. 2007. Brief on National Forest Inventory – Myanmar. Accessed on 20 October 2012 from <http://www.fao.org/forestry/18235-0f3b0fe3d30c9a36cd09f449ed339d87c.pdf>

This report provides an overview on the national forest inventory of Myanmar. It documents both the historical and current variables, specifications, sampling designs, and methods used in the national forest inventory. The report includes maps, details about land area and land use, design of the inventory (including remote sensing and field inventory), and the



methodology used for data collection. The methodology includes aspects such as biophysical and geophysical data, forest characteristics, social services, forest distribution, biodiversity, goods and services, policy, legal, and institutional frameworks.

Food and Agriculture Organization of the United Nations. 2009. Digital Agricultural Atlas. Accessed on 10 October 2012 from [http://dwms.fao.org/atlas/myanmar/atlas\\_en.htm](http://dwms.fao.org/atlas/myanmar/atlas_en.htm)

This valuable webpage from the FAO provides the digital information available as part of Myanmar's agricultural atlas from 2001-2002. This includes maps relating to agricultural and other relevant information. Categories of maps available include: political and administrative, population density, rainfall, net sown areas, irrigated areas, rice crop, cattle, horticulture crops, mechanization, aquaculture, and fertilizers/pesticides. In addition to PDF versions of some maps, the site also hosts some interactive maps as well as the ability to download files to view using Google Earth. Users on Windows-based systems can also download a very large (600MB+) desktop version of the atlas, which includes all maps and a specialized user interface.

Food and Agriculture Organization of the United Nations. 2010. Country Profile: Food Security Indicators. Country: Myanmar. Accessed on 23 October 2012 from [http://www.fao.org/fileadmin/templates/ess/documents/food\\_security\\_statistics/country\\_profiles/eng/Myanmar\\_E.pdf](http://www.fao.org/fileadmin/templates/ess/documents/food_security_statistics/country_profiles/eng/Myanmar_E.pdf)

This brief country profile of food security indicators for Myanmar includes data and statistical information from 1990 to 2007. Information includes: (i) Food deprivation and consumption indicators (food deprivation, food needs, food supply for human consumption, diet consumption, and major food commodities consumed); (ii) Food production indicators (role of production to consumption by major commodity); (iii) Food trade indicators (foreign food trade, role of imports to consumption by major commodity, food aid received); (iv) Macro and socioeconomic indicators (population, macro economic aggregates, poverty, inequality in access to food and to income, literacy rate); and (v) Agriculture indicators (agricultural inputs, land, agricultural production, major exports, inputs, and investments in agriculture).

Food and Agriculture Organization of the United Nations. 2012. Aquastat – Country Fact Sheet – Myanmar. Accessed on 21 October 2012 from [http://www.fao.org/nr/water/aquastat/data/factsheets/aquastat\\_fact\\_sheet\\_mmr\\_en.pdf](http://www.fao.org/nr/water/aquastat/data/factsheets/aquastat_fact_sheet_mmr_en.pdf)

This country fact sheet for Myanmar includes tabulated information on land and population, water resources, water withdrawal, and water managed areas. It is a basic one-pager with date of the data and the value and units.

Food and Agriculture Organization of the United Nations. 2012. FAO Country Profile for Myanmar. Accessed on 9 October 2012 from <http://www.fao.org/countryprofiles/index/en/?lang=en&ISO3=MMR>

This website is a central repository for agriculture-related resources for Myanmar, with a strong emphasis on those produced by FAO and partner UN/multilateral agencies. Linked



resources include thematic profiles, news items, and statistics and maps covering natural resources, economic conditions, and the agriculture, forestry and fisheries sectors. The site does not provide analysis and is not easily searchable – it is not a database, but a collection of webpages with links to other related websites and resources.

Food Security and Agriculture Thematic Group. 2010. Framework for Action for the Central Dry Zone, Myanmar. Accessed on 23 October 2012 from <http://www.myanmarfswg.net/pdf/Dry%20Zone%20%20Action%20Plan%2023%20July%202010.pdf>

This framework of action, drafted by the multi-agency Food Security and Agriculture Thematic Group, focuses on the Dry Zone of Myanmar. It provides an introduction and background to the dry zone and its issues. Also included are key challenges, government priorities, a needs analysis, action areas of the program (dry land farming, environmental protection, access to credit, water management, and capacity building). It also includes details on arrangements for implementation across multiple donors and actors (e.g., CARE, FAO, UNICEF, PSI, and the Ministry of Health).

Food Security Information Network. 2012. Food Security Information Network Bulletins. Accessed on 27 November 2012 from [http://www.fsinmyanmar.net/index.php?option=com\\_k2&view=item&layout=item&id=224&Itemid=127](http://www.fsinmyanmar.net/index.php?option=com_k2&view=item&layout=item&id=224&Itemid=127)

This site includes bulletins on food security for the month of May 2012 provides information on the current planting period, areas with high food insecurity, its current status and projections for three and six months. The crop production outlook includes a list of areas being monitored, highlighting the main crops and level of production. It includes maps and narratives on food availability and consumption patterns, and also brief narratives on food security situation by state. This differs from the WFP Food Security Update as it is more detailed and includes details on regions (while the WFP has less details and narratives on regional impacts).

Hadden, R. Lee. 2008. The Geology of Burma (Myanmar): An Annotated Bibliography of Burma's Geology, Geography and Earth Science. Accessed on 21 October 2012 from <http://www.tec.army.mil/Burma/BurmaWater.pdf>

This bibliography was prepared by the Topographic Engineering Center to assist with the humanitarian efforts carried out by the US Government after Cyclone Nargis in 2008. Information included is topography, transportation, water, medical concerns, and security. It also includes information such as weather and climate, terrain, forestry, geology, groundwater, hydrology, mining, and soils. It also includes satellite images showing the damage caused by the cyclone. There are links to resources that were used to develop the bibliography.

Htun, Khin. 2009. Myanmar Forestry Outlook Study. Accessed on 20 October 2012 from <http://www.fao.org/docrep/014/am252e/am252e00.pdf>

The Myanmar Forestry Outlook Study is a part of the larger Asia-Pacific forestry sector outlook study done by the FAO. This document provides an overview of the forestry sector in Myanmar. It includes various aspects of the forestry sector such as the role of the sector and the current state of forests and forestry in Myanmar, including the products and services, policy, institutional framework, and problems. It also includes the factors that are expected to influence the sector and discusses probable scenarios and other implications. It sets a vision for 2020 and provides information on improving the sector.

Information Technology for Humanitarian Assistance, Cooperation and Action. 2012. Maps – Myanmar. Accessed on 20 October 2012 from <http://www.ithacaweb.org/maps/myanmar/>

This website offers almost 50 maps for Myanmar, include maps on disasters, climate, and related information. The maps are intended to support humanitarian assistance work in the country following disasters. They include flood frequency from 2000-2010 for various monsoon months, average rainfall conditions, satellite-detected water body extent, and high-resolution detailed maps of areas affected by flooding from Cyclone Nargis in 2008. JPG versions of the maps are available for download.

Livelihoods and Food Security Trust Fund. 2012. Baseline Survey Results. Accessed on 23 October 2012 from <http://www.lift-fund.net/downloads/LIFT%20Baseline%20Survey%20Report%20-%20July%202012.pdf>

LIFT is a multi-donor fund designed to increase food availability and incomes of 2 million poor and vulnerable people in Myanmar. It began new programs of support in the Delta/Coastal, Hilly, and Dry zones of Myanmar in 2011. LIFT conducted a baseline survey covering 252 villages in late 2011 to provide information that could be used to assess the outcomes and impacts of this support. The report has the findings of the survey. It also includes the objective, methodology, village profiles, findings (e.g., demographic information, income, food security, access to land and cultivation, household crop production, and training). The report also provides the surveys used in the study. The outcomes revealed the great regional disparities in livelihoods and food security, with the Delta/Coastal Zone having the greatest inequity among households.

Livelihoods and Food Security Trust Fund. 2012. Delta 1 Evaluation Report. Accessed on 8 October 2012 from <http://www.lift-fund.net/downloads/Delta%201%20Evaluation%20Report.pdf>

The Livelihoods and Food Security Fund (LIFT) was set up to support the achievement of Millennium Development Goal 1 (the eradication of extreme poverty and hunger) by sustainably increasing food availability and incomes of two million target beneficiaries in Myanmar. This comprehensive report initially sets the background and details the objective and methodology of the study, followed by the findings. It discusses which activities have been effective for rice farmers in increasing their incomes, and which had mixed effects and why. It also considers sustainability, mode of provision, and methods of training. This is followed by an overview of the activities targeting the poor and vulnerable to increase cost-effectiveness. The report includes significant qualitative analysis substantiated by many quotes from program participants.

Ministry of Agriculture and Irrigation. 1999. Myanmar. Accessed on 10 October 2012 from <http://www.unescap.org/rural/doc/sads/myanmar.PDF>

The UNESCAP webpage on Sustainable Agricultural Development Strategies for the Least Developed Countries of the Asian and the Pacific Region includes this overview of Myanmar. The chapter provides an assessment of the current state of agriculture, forestry, and marine resources, including some of the challenges faced by these sub-sectors. It also looks at the impact of agricultural policies on sustainable development and reviews relevant policies. Also included are strategies for sustainable agricultural development and recommended policies.

Ministry of Agriculture and Irrigation. 2002. Soil Types and Characteristics of Myanmar. Accessed on 22 October 2012 from [www.themimu.info/docs/Govt\\_Soil-types-description\\_Feb\\_2002.pdf](http://www.themimu.info/docs/Govt_Soil-types-description_Feb_2002.pdf)

This comprehensive document from the Ministry of Agriculture and Irrigation of Myanmar contains details about the soil types and their characteristics. The document describes and introduces the main soil types found in the country, and then provides details by state. Also included are soil maps. Note that the document only contains the first several pages of the report – unable to locate the complete version.

Ministry of Agriculture and Irrigation. 2009. Challenges of Climate Change and Food Security. Accessed on 11 October 2012 from [http://www.foodsecuritylink.net/myanmar/index.php?option=com\\_remository&Itemid=13&func=startdown&id=89](http://www.foodsecuritylink.net/myanmar/index.php?option=com_remository&Itemid=13&func=startdown&id=89) (link may no longer work)

This paper by Myanmar's Ministry of Agriculture and Irrigation provides an introduction to the challenges of food security due to climate change. It highlights some of the impacts, the current situation in ASEAN countries, impacts on food security and sustainable development caused by climate change, and types of action needed. The paper also addresses greenhouse gas mitigation concerns in the context of agriculture and food security. There are two case studies, one on groundwater irrigation in Meikhtilar-Thazi and the second on small tank irrigation in Yamethin areas.

Ministry of Environmental Conservation and Forestry. 2011. National Biodiversity Strategy and Action Plan. Accessed on 25 January 2013 from <http://www.cbd.int/doc/world/mm/mm-nbsap-01-en.pdf>

This government document, supported by funds from the United Nations Environment Programme (UNEP) and GEF, outlines a comprehensive framework for a sustainable approach to biodiversity conservation and promotion. In addition to valuable background data and summaries of current biodiversity conditions throughout the country, including principal threats, the report provides priority actions and proposes strategies for protecting biodiversity (including for agricultural purposes).

Myanmar Egress; International Development Enterprises (IDE) Myanmar, Asia Languages and Business Academy (Alba) Myanmar; and The Myanmar Rice Association. 2010. Rejuvenating the Rice Sector in Myanmar: Expanding Yields and Profits through the Rice Chain while Retaining Domestic Price Stability.

The paper reviews research done on the rice sector by several institutions in Myanmar and examines various aspects of the market chain relating to rice. It identifies blockages and possible solutions for removing them. It is intended to contribute to recommended policy change in the country. It looks at various aspects of rice production including yield, stability of prices, expansion, farm practices, milling, trading and exporting, the need for credit, necessary legislative changes, and institutional strengthening. It also summarizes key recommendations based on the review.

Myanmar Information Management Unit. 2012. Agriculture Livelihoods Food Security. Accessed on 21 October 2012 from [http://themimu.info/Agriculture\\_Livelihoods\\_Food\\_Security/index.php](http://themimu.info/Agriculture_Livelihoods_Food_Security/index.php)

This webpage of the Myanmar Information Management Unit (MIMU) focuses on agriculture, livelihoods, and food security. It provides links to maps (livestock), microfinance, assessments on food security, working group meeting minutes and presentations, reference documents, and technical guides. The MIMU site also offers links to a variety of information products (e.g., baseline data, township profiles, and contact lists) and resources for a range of sectors (e.g., environment, health, nutrition, and shelter). One section provides the Who, What and Where for organization and activities operating in Myanmar on agriculture and food security.

Naing, Tin Aye Aye, Soe Soe Thein, M. Finckh, and A. Buerkert. 2002. International Symposium Food Security and Managing Natural Resources in Southeast Asia – Challenges for the 21st Century. Effects of Increasing Cropping Intensity on Rice Production in Myanmar. Accessed on 20 October 2012 from [https://www.uni-hohenheim.de/fileadmin/einrichtungen/sfb564/events/uplands2002/Full-Pap-S3A-1\\_Naing.pdf](https://www.uni-hohenheim.de/fileadmin/einrichtungen/sfb564/events/uplands2002/Full-Pap-S3A-1_Naing.pdf)

The paper is based on a field study carried out to understand rice cultivation practices and cropping patterns practiced by local farmers and to identify constraints of low and declining rice yield. The study included farm size, fertilizer used, number of crops per year, disease, and pesticides. Conclusions state that application of the mineral Nitrogen (N) and the role of fungicides and insecticides play a larger role than herbicides and that the use of N can lead to increased disease incidence, although the effects are site specific and reflect more complicated interactions with soil properties.

NASA Socioeconomic Data and Applications Center (SEDAC), hosted by the Center for International Earth Science Information Network at Columbia University. 2012. Myanmar. Accessed on 22 October 2012 from <http://sedac.ciesin.columbia.edu/search/data?contains=myanmar>

This webpage links to SEDAC resources that include maps and datasets on Myanmar. Topics include population, landscape, and climate estimates, Environmental Performance Index,

Natural Resource Management Index, population density, administrative boundaries, coastlines, and roads. Information is available as tables, raw data, documents, and maps. NASA Socioeconomic Data and Applications Center (SEDAC), hosted by the Center for International Earth Science Information Network at Columbia University. 2012. Spatial Data Catalog – Burma. Accessed on 22 October 2012 from <http://sedac.ciesin.columbia.edu/geonetwork/srv/en/cu-gis.search?extended=off&remote=off&attrset=geo&any=burma>

The Columbia University spatial data catalog includes various maps and spatial data relating to Myanmar. This link (when the catalog is searched using the keyword Burma) provides links to all the resources available on Myanmar. Some of the information includes elevation, land cover, land use, built up areas, coast line, settlements, vegetation, transport networks, and climate datasets.

Poe, Claudia Ah. 2011. Food Security Assessment in Northern Rakhine State Myanmar. Accessed on 23 October 2012 from <http://documents.wfp.org/stellent/groups/public/documents/ena/wfp234781.pdf>

This report from the World Food Programme is a food security assessment done in the Northern Rakhine State in Myanmar. It includes background information and also the food security status and trends for information such as how many people, which areas and who are those affected by food insecurity. It includes demographic, livelihood, and asset information. It also identifies key vulnerability issues and opportunities, including aspects such as agriculture, migration, indebtedness, education, water and sanitation, shocks, and coping. It concludes by looking at ways in which food security can be ensured.

Romano, Paolo. 2010. Food Security Data Management Requirement Analysis and Technical Capacity Assessment – Myanmar. Accessed on 22 October 2012 from [http://www.foodsec.org/fileadmin/user\\_upload/eufao-fsi4dm/docs/Romano%20-%20Myanmar%20Food%20Security%20Data%20Management%20Requirement%20Analysis%20and%20Technical%20Capacity%20Assessment.pdf](http://www.foodsec.org/fileadmin/user_upload/eufao-fsi4dm/docs/Romano%20-%20Myanmar%20Food%20Security%20Data%20Management%20Requirement%20Analysis%20and%20Technical%20Capacity%20Assessment.pdf)

This FAO document presents findings of an International Data Management and GIS Consultant mission to Myanmar under the EC-FAO Food Security Programme, project Linking Information and Decision Making to Improve Food Security. The aim was to assess the country requirements and technical capacity for improved food security data management, analysis and information dissemination through consultations with relevant institutions. The document includes an overview of the current status on food security related information (including who hosts certain information and their capacity and willingness to share) and makes several recommendations for improving data management capacity.

Smithsonian – National Museum of Natural History. Checklist of the Plants of Myanmar: Distribution by State and Division. Originally from *Checklist of the Trees, Shrubs, Herbs, and Climbers of Myanmar*, Contributions from the United States National Herbarium. Volume 45: 1-590. 2003. Accessed online on 22 October 2012 from <http://botany.si.edu/myanmar/geography/distribution.cfm>

The webpage has links to checklists of plants by region, and under each region the scientific names of plants are listed under group names.

Springate-Baginski, Oliver, Maung Maung Than, Naw Hser Wah, Ni Ni Win, Khin Hnin Myint, Kyaw Tint, and Mehm Ko Ko Gyi. 2011. Community Forestry in Myanmar: Some Field Realities. Accessed on 23 October 2012 from <http://www.burmalibrary.org/docs13/CF+Myanmar+report+-+FUG+case+studies-op75-red.pdf>

This report on community forestry in Myanmar focuses on the realities on the ground. It provides an introduction to community forestry in Myanmar. The report includes experiences from 16 randomly selected Forest User Groups from across the country. These areas were visited by a research team in late 2010 during a Community Forestry study conducted by ECCDI, with technical support from the School of International Development, University of East Anglia, under funding support from the Pyoe Pin programme. The report highlights many of the challenges faced by these groups and explores possibilities for future expansion of such programs.

United Nations Development Programme. 2004. Myanmar – Agricultural Sector Review Investment Strategy. Volumes 1 and 2. Sector Review. Access on 10 October 2012 from [http://www.mm.undp.org/UNDP\\_Publication\\_PDF/ASR%20Vol.1%20Sector%20Review.pdf](http://www.mm.undp.org/UNDP_Publication_PDF/ASR%20Vol.1%20Sector%20Review.pdf) and [http://www.mm.undp.org/UNDP\\_Publication\\_PDF/ASR%20Vol.2%20Investment%20Strategy.pdf](http://www.mm.undp.org/UNDP_Publication_PDF/ASR%20Vol.2%20Investment%20Strategy.pdf)

This extensive review, conducted by FAO on behalf of the Government of Myanmar and UNDP, offers a wide-ranging survey and analysis of the agricultural sector (including livestock and fisheries, but not forestry), providing sector potentials and future investment strategies to address rural poverty. Various sub-sector analyses (e.g., for irrigation and water resources, agro-industry, crop production, community development, and extension) contribute to sector-wide conclusions and recommendations. The output is technical and includes GIS maps and data (integrated into the Agricultural Atlas of Myanmar). The report provides analysis of policy as well as significant amounts of data and statistics. The second volume offers a wide-ranging survey and analysis of the agricultural sector with respect to investment strategy and sector investment profiles. It includes sub topics such as crop production, livestock production, fisheries investment, agro-industry, irrigation and water resources, and rural financing. In many of these, the authors detail opportunities, constraints, investment strategies, and profiles.

United Nations Development Programme. 2011. Integrated Household Living Conditions Survey in Myanmar (2009-2010). Accessed on 22 October 2012 from <http://www.mm.undp.org/ihlca/index.html>

This webpage by the United Nations Development Programme focuses on the Integrated Households Living Conditions Survey, which was done to determine poverty levels, household living conditions and the MDG indicators for Myanmar. It has information relating to the first and second such surveys done in the country. It also provides links to a UNDP press release which states that the second nation-wide Household Living Conditions survey shows progress in poverty reductions although challenges remain. It provides links to the Poverty Profile Report, Poverty Dynamics Report, MDG-Data Report, Technical Report, and Quality Report.



University of Texas at Austin. 2012. Perry-Castañeda Library Map Collection. Burma (Myanmar) Maps. Accessed on 22 October 2012 from <http://www.lib.utexas.edu/maps/burma.html>

This map collection includes several maps of Myanmar. Maps available are from a wide range of years, including historical maps dating as far back as 1827. Other maps include those of administrative divisions, political, and relief. Thematic maps include economic activity and land use, ethno linguistic groups, and population. It also includes several topographic maps.

U.S. Army Corps of Engineers. 2010. Maps of Burma. Accessed on 23 October 2012 from <http://www.tec.army.mil/Burma/BurmaMap.html>

This webpage has a collection of recent and older maps of Myanmar. Some of the maps include geology, climatic regions, landsat images, Mekong watershed, transportation, ethnic groups, forest land use, and land use. It also provides links to other websites that have maps of Myanmar.

Water Environment Partnership in Asia. 2012. State of Water Environmental Issues – Myanmar. Accessed on 21 October 2012 from <http://www.wepa-db.net/policies/state/myanmar/myanmar.htm>

This website includes tabulated information on Myanmar. Information includes types of land, area, water resources and the status of its utilization, potential water sources (river basins, catchment area, and inflow), potential groundwater (river basin, catchment area, and inflow), the present status of the water environment, and water quality of reservoirs.

Win, U Hla. 2004. Aquaculture Opportunities and Challenges. Accessed on 11 October 2012 from <http://library.enaca.org/AquacultureAsia/Articles/April-June-2004/4opportunities-myanmar.pdf>

This brief article on aquaculture in Myanmar provides an overview and status of aquaculture, targets, mariculture, freshwater culture, and challenges of the sector. Additionally, it looks at the socioeconomic aspects of aquaculture.

World Food Programme. 2012. Food Security Update September 2012 – Key Events and Early Warning (Myanmar). Accessed on 17 October 2012 from <http://documents.wfp.org/stellent/groups/public/documents/ena/wfp251599.pdf>

This brief 2-page document gives an update on food security in Myanmar as of September 2012. It outlines the situation of food security and the key events relating to food insecurity by state. It summarizes actions taken and needed. It also lists food security issues and areas in which food security is manifest, with brief details on the situation. This differs from the FSIN bulletin as this update is brief and has less details on the food security situation in each region (it also does not include maps).

World Food Programme. 2012. Myanmar – Overview. Accessed on 22 October 2012 from <http://www.wfp.org/countries/myanmar/overview>

This webpage by the World Food Programme provides an overview on Myanmar focusing on poverty aspects. It provides links to recent stories on topics such as disasters and poverty. It provides links to latest resources on Myanmar. It includes WFP projects and activities in Myanmar. Other links include media and contacts.

### **A.2.2. Global/Regional Data Sets, Maps and Resources**

Fischer, Günther, Harrij van Velthuisen, Freddy Nachtergaele, and Serge Medow. 2000. Global Agro-Ecological Zones. Accessed on 12 October 2012 from <http://webarchive.iiasa.ac.at/Research/LUC/GAEZ/index.htm>

This webpage contains the information of a CD-ROM produced in 2000 on Global Agro-Ecological Zones. Its web archive includes information last updated in 2000. It contains a presentation on agro-ecological zones, a summary, introduction, methodology, land resources, results, data, and limitations. In addition, it includes figures, graphs, tables, plates, and pictures. Some of the results included are climate, soil and terrain assessments, crop yields, irrigation, and land cover.

Food and Agriculture Organization of the United Nations. 2011. Selected Indicators of Food and Agricultural Development in the Asia-Pacific Region 2000-2010. Accessed on 19 October 2012 from <http://www.fao.org/docrep/014/i2371e/i2371e00.pdf>

This comprehensive document reviews food and agricultural development over the past decade using selected indicators in the Asia-Pacific region. It provides brief country profiles, and information is also available by country for the following: agricultural land and population, agricultural inputs, production indices, staple food crops, edible oil crops, horticultural crops, fibre crops, other crops, livestock, agricultural trade, fisheries, forestry, nutrition, and other indicators, including organic farming and biofuels. Statistics are also presented using graphs and maps.

Food and Agriculture Organization of the United Nations and International Institute for Applied Systems Analysis. 2012. FAO Statistical Yearbook 2012. Accessed on 23 October 2012 from <http://www.fao.org/economic/ess/ess-publications/ess-yearbook/yearbook2012/en/>

This webpage contains the 2012 edition of the FAO Statistical Yearbook. This publication is a visual synthesis of the major trends and factors relating to global food and agriculture including interrelated factors, such as the broader environmental, social, and economic dimensions. It is a useful reference source on the state of world food and agriculture for policy-makers, donor agencies, researchers, analysts, and the general public. The book is subdivided into four thematic parts, which include (i) The setting, (ii) Hunger dimensions, (iii) Feeding the world and (iv) Sustainability dimensions. It includes limited information and statistics on Myanmar, where available.



Food and Agriculture Organization of the United Nations. 2012. Food Security Indicators. Accessed on 21 October 2012 from <http://www.fao.org/economic/ess/ess-fs/fs-data/ess-fadata/en/>

This webpage contains the initial set of indicators aiming to capture various aspects of food security following the recommendation of experts that gathered in the Committee on World Food Security Round Table on hunger management. It includes determinants of food security, which include availability, physical access, economic access (affordability), and utilization. Outcomes tracked include inadequate access to food, utilization; and vulnerability/stability indicators which include aspects such as price volatility, production, and supply variability. The data is downloadable as an excel file and include data by country, including Myanmar (only some indicators have data available).

Food and Agriculture Organization of the United Nations and International Institute for Applied Systems Analysis. 2012. Harmonized World Soil Database (version 1.2). FAO, Rome, Italy and IIASA, Laxenburg, Austria. Accessed on 22 October 2012 from <http://webarchive.iiasa.ac.at/Research/LUC/External-World-soil-database/HTML/>

The Harmonized World Soil Database contains a downloadable database. The database has been prepared using large volumes of recently collected regional and national updates of soil information, each of which have been assimilated and harmonized by IIASA. It includes a raster, database, and viewer software. Information includes organic carbon, pH, water storage capacity, soil depth, cation exchange capacity of the soil and the clay fraction, total exchangeable nutrients, lime and gypsum contents, sodium exchange percentage, salinity, textural class, and granulometry.

Food and Agriculture Organization of the United Nations. 2012. FAOSTAT. Accessed on 8 October 2012 from <http://faostat3.fao.org/home/index.html#VISUALIZE>

This online database provides access to global agricultural production information in the form of maps, graphs, and tables. It has data ranging from 1961 to 2010 and includes information on production, food balance sheets, food supply, commodity balance, and forestry. It includes both global and country-level information. Searches can be done by domain and by country. There is an extensive amount of information housed in this database. The site also offers the ability to compare data across countries and apply tools to run analysis (e.g., regression, maximum/minimin studies, and correlation matrices).

Food and Agriculture Organization of the United Nations. 2012. GeoNetwork. Accessed on 10 October 2012 from <http://www.fao.org/geonetwork/srv/en/main.home>

The GeoNetwork website from FAO is an online database which contains geo-spatial data. It contains interactive maps, GIS datasets, satellite imagery, and other related applications. Information available includes categories such as administrative and political boundaries, agriculture and livestock, ecology, base maps, climate, fisheries and aquaculture, hydrology and water resources, land cover and land use, population and socioeconomic indicators, soil and soil resources, and topography. Users are able to find and run maps on their interactive platform, which can be used to zoom in to view data specific to Myanmar.

Humanitarian Early Warning Service. 2012. Humanitarian Early Warning Service. Accessed on 20 October 2012 from <http://www.hewsweb.org/hp/>

This website provides up to date warning information on various hazards and contains global information. It includes mapped information for hazards covered such as floods, storms, seismic, volcanoes, drought, and others. It has a section on the latest news and information available by country. This website has been developed and is maintained by the World Food Programme.

Iglesias, Ana and Cynthia Rosenzweig. 2010. Effects of Climate Change on Global Food Production under SRES Emissions and Socio-economic Scenarios. Accessed on 22 October 2012 from <http://sedac.ciesin.columbia.edu/data/set/crop-climate-effects-climate-global-food-production/data-download>

The maps tab on this webpage shows project yield change for maize, rice, and wheat under various climate change scenarios. This website also provides a link to the excel data file on the 'Effects of Climate Change on Global Food Production from SRES Emissions and Socioeconomic Scenarios, v1 (1970–2080)'. This data set provides an assessment of potential climate change impacts on world staple crop production (wheat, rice, and maize), with a focus on quantitative estimates of yield changes based on multiple climate scenario runs. The data set assesses the implications of temperature and precipitation changes for world crop yields taking into account uncertainty in the level of climate change expected and physiological effects of carbon dioxide on plant growth.

International Research Institute for Climate and Society and World Bank. 2012. World Bank Climate Change Data Portal GHCN Station Temperature & Precipitation Variability Tool. Accessed on 20 October 2012 from [http://iridl.ldeo.columbia.edu/maproom/.Global/.World\\_Bank/.Climate\\_Variability/](http://iridl.ldeo.columbia.edu/maproom/.Global/.World_Bank/.Climate_Variability/)

This website contains an interactive map that to search historical variability of precipitation and temperature at various time scales. Time scales available include interannual, decadal, and long-term linear trend. Data is available from 1901 to 2000. Unfortunately, there is only one station with valid data in Myanmar accessible via this map interface, and the time series data is very limited for that station. There are stations in nearby countries that may be used.

International Rice Research Institute. 2012. World Rice Statistics. Accessed on 10 October 2012 from [http://www.irri.org/index.php?option=com\\_k2&view=itemlist&layout=category&task=category&id=744&Itemid=100346&lang=en](http://www.irri.org/index.php?option=com_k2&view=itemlist&layout=category&task=category&id=744&Itemid=100346&lang=en)

This webpage of the International Rice Research Institute has information on rice production and related data from around the globe, including Myanmar. It includes collated information from various sources such as the FAO and USDA. The site contains data on rice area, production, and yield over time, rice imports, exports, national farm-level and world rice prices, and other rice supply and demand statistics. The online query web page provides access to a searchable database where the information mentioned above can be searched, while the mapping page allows the visual display of a selection of statistics and information.

International Soil Reference and Information Centre – World Soil Information. 2012.  
Accessed on 24 October 2012 from <http://www.isric.org/content/welcome-isric-world-soil-information>

This World Soil Information website includes information, datasets and maps relating to soil. It has downloaded data on soil information at the global and national level. The world soil database includes information and visualization of soil profile data as well as area-class soil maps. It also includes links to a metadata service and also has links to Worldgrids.org which has gridded repositories of Digital Soil Mapping.

Siebert, Than, Petra Döll, Sebastian Feick, Jippe Hoogeveen, and Karen Frenken. 2007.  
Global Map of Irrigation Areas version 4.0.1. Johann Wolfgang Goethe University,  
Frankfurt am Main, Germany/Food and Agriculture Organization of the United Nations,  
Rome, Italy. Accessed on 26 October 2012 from  
<http://www.fao.org/nr/water/aquastat/irrigationmap/MMR/index.stm#table>

This webpage contains the latest version of the *Global Map of Irrigation Areas* which can be downloaded from the page. The map shows the area equipped for irrigation/actually irrigated area. Terminology used to indicate areas under irrigation is given in a glossary. It includes an explanation of the methodology, information per country, map quality, and background and history of the project. Data is available in GIS format and is available for download (PDF). The page on Myanmar has a few details specifically relating to the irrigated areas of the country.

K. Tse-ring, E. Sharma, N. Chettri, and A. Shrestha (eds). 2010. Climate Change  
Vulnerability of Mountain Ecosystems in the Eastern Himalayas – Synthesis Report.  
Kathmandu: ICIMOD. Accessed on 24 January 2013 from  
<http://www.icimod.org/publications/index.php/search/publication/696>

This report assesses the projected climate change impacts and vulnerabilities for the Eastern Himalayas, which includes the Chin and Kachin States in Myanmar. The analysis focuses on the ecosystem impacts, but with analysis of how changes in the climate and ecosystems may affect other sectors and socioeconomic aspects of the targeted region. The report includes some maps, statistics and figures on regional impacts, with a few specific details addressing the conditions in Myanmar.

United States Department of Agriculture. 2012. Foreign Agricultural Service. Crop Explorer.  
South East Asia. Accessed on 21 October 2012 from  
<http://www.pecad.fas.usda.gov/cropexplorer/imageview.cfm?regionid=seasia>

This webpage by the USDA includes near real-time information on for 10-day average precipitation. Data can be viewed either in the online interactive map viewer or on Google Earth. Other information links include: weather, soil moisture, satellite data, and growing season. Clicking on the maps links to charts showing historical and current data.

United States Department of Agriculture. 2012. Global Agriculture Monitoring Viewer. Accessed on 8 October 2012 from <http://glam.gdacorp.com/GLAMViewer/>

This online database includes near real-time satellite data and provides information on NDVI, vegetation, cultivated area, land cover, and other variables. This is presented in the form of an interactive global map in which the user can zoom in on specific regions and countries. The map can be used to view a wide range of layers and datasets from various satellite products.

United States Department of Agriculture. 2012. Global Agricultural Information Network Online. Accessed on 10 October 2012 from <http://gain.fas.usda.gov/Lists/Advanced%20Search/AllItems.aspx>

This online database provides access to reports produced by the U.S. Department of Agriculture's Foreign Agricultural Service. These reports include country-specific production and export data for a variety of crop categories including beans and pulses, and specific crops such as rice, corn, and wheat. Other resources offer analysis of agriculture market conditions and trends for the country, with a focus on export-oriented assessment. There are numerous reports for Myanmar, and they are updated frequently.

United States Geological Survey. 2012. EarthExplorer. Accessed on 22 October 2012 from <http://earthexplorer.usgs.gov/>

This webpage from the USGS is a searchable database and map interface. It allows searching by area, features, and coordinates. This is a global database and datasets include aerial photography, digital elevation, forest carbon sites, land cover, global land survey, landsat data, and LIDAR vegetation monitoring.

University of Maryland. 2012. 250-meter MODIS/NDVI Time Series Database – Asia, Southeast. Accessed on 21 October 2012 from [http://pekko.geog.umd.edu/usda/beta/index.php?orig\\_region\\_id=-1&region\\_id=16](http://pekko.geog.umd.edu/usda/beta/index.php?orig_region_id=-1&region_id=16)

The webpage includes MODIS/NDVI maps/images by region including Southeast Asia, which shows Myanmar. It contains satellite images from 2000 onwards. The resolution of some images can be as high as 250 meters.

World Bank. 2013. World Data Bank – World Development Indicators and Global Development Finance (GDF). Accessed on 20 October 2012 from <http://databank.worldbank.org/ddp/home.do> or <http://databank.worldbank.org/data/home.aspx>

World Development Indicators (WDI) is the primary World Bank database for development data from officially-recognized international sources. Global Development Finance (GDF) provides external debt and financial flows statistics for countries that report public and publicly-guaranteed debt under the World Bank's Debtor Reporting System (DRS). Information available includes world development indicators and global development finance, gender statistics, health, nutrition and population statistics, Millennium Development Goals, poverty, and inequality.

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[http://www.mm.undp.org/UNDP\\_Publication\\_PDF/ASR%20Vol.2%20Investment%20Strategy.pdf](http://www.mm.undp.org/UNDP_Publication_PDF/ASR%20Vol.2%20Investment%20Strategy.pdf)
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