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Review of the Impact of Climate Change on Agriculture and Existing Mitigation and Adaptation Strategies in Myanmar

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1. Introduction

Climate change can be described as a variation in the earth's usual temperature taking place typically over decades or over a century.[1] Myanmar is a largely agrarian country located in mainland Southeast Asia and was ranked as the second most vulnerable country in the world in terms of climate change hazards. Observation reveals changes in climatic indicators such as: (1) rising temperatures; (2) prolonged drought; (3) more frequent cyclone attacks and flooding; and (4) intense rain.[2] These changing climatic conditions have a negative impact on the agricultural sector, reducing productivity and causing huge financial loss which affects the majority of the population. To reduce vulnerability, mitigation and adaptation strategies have been deployed by the government with support from international donors. In this review, the term 'mitigation' relates to the cause of climate change and work to lessen the man-made effects on climate systems. 'Adaptation' means activities that have been prepared or carried out to reduce the effect of climate change, thus minimizing the vulnerability of communities and ecosystems.[1, 3]

This paper addresses the following research questions:

- How has climate change impacted agricultural development in the country and how severe has this impact been?
- What are the existing mitigation and adaptation strategies?
- How responsive and effective have these mechanisms been?

The review is based entirely on existing literature and data extracted from various sources such as government official websites, the World Development Indicators, FAOSTAT, other country socio-economic data and the webpages of development agencies.

The report consists of six parts. The first section provides an overview of the geographical setting of the country. The second addresses the progress of economic growth and the development of the agricultural sector, leading to a specific discussion of the characteristics of the country's agro-ecological zone. Section three reflect current agricultural development and climate change phenomena. Section four assesses the impact of climate change on agriculture. Again, it looks specifically into the impact on different agro-ecological zones. The existing climate change mitigation and adaptation strategies are then provided in section 5. The last section gives the conclusion.

2. Geographical Settings

The Republic of the Union of Myanmar is located on the mainland of Southeast Asia between 09° and 28°N and 92° and 101°E. The country is bordered by India, Bangladesh, Thailand, Lao PDR and China, and along its coastline are the Andaman Sea and Bay of Bengal to the south (Figure 1). The total land area of the country is 676,552 km², being divided into seven Regions and seven States. [2]

Figure 1: Map of Myanmar



Source: http://dwms.fao.org/atlasses/myanmar/atlas_en.htm

In 2015, about 19.5 percent of the country was agricultural landⁱ, a steady increase from 16 percent in the early '90sⁱⁱ (Table 1). The total population in 2014 was 51.48 million with an annual growth rate of 0.89 percent. The most populous regions are Yangon (7.36 million), Ayeerawaddy (6.18 million), Mandalay (6.16 million), Shan (5.82 million) and Sagaing (5.32 million). The remaining 9.5 percent of the population is distributed across Kayah (286,000), Chin (478,000), Nay Pyi Taw (1.16 million), Taninthayi (1.40 million) and Kayin (1.57 million).[2]

ⁱ Agricultural land refers to the share of the land area that is arable, under permanent crops, and under permanent pasture.

ⁱⁱ About half of country's total area remain under forest.

Table 1: Myanmar's Agricultural Land by Year

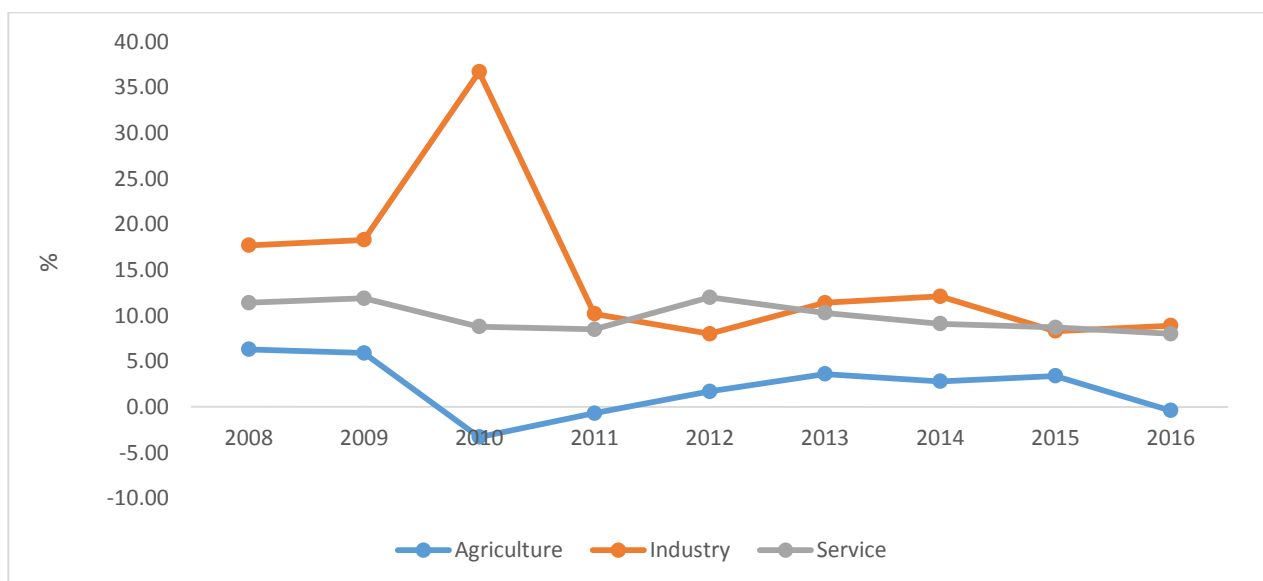
Year	1990	2000	2008	2009	2010	2011	2012	2013	2014	2015
Agricultural Land (% of total land)	16.0	16.5	18.8	19.0	19.2	19.2	19.2	19.3	19.4	19.5

Source: World Development Indicators Series 2017

3. Agricultural Development

The major political and economic reform in 2010 paved the way for significant economic growth.[4, 5] The GDP growth of the country was 5.6 percent in 2012. Since then the average growth until 2017 was slightly above 7 percent before dropping to 5.9 percent due to the impact of cyclone Komen in 2015.[6] Agricultural growth has fluctuated but has been minimal overall, with negative growth in 2010, and barely above 5 percent since 2012 (Figure 2). This reflects the fact that the rise or drop in agricultural production can be related to climate-related natural disasters and a weak capacity to adapt to climate change due to limited irrigation coverage. [2, 6, 7] The growth rate of industry sector in 2010 was almost tripled with opening of foreign direct investment (FDI) and economic liberalization, including the utilization of gemstones, minerals, oil and natural gas.[8] The effect of the severe flood in 2015 exemplified how vulnerable the agriculture sector of the country is to adverse climatic conditions. Although the country is facing challenges in the process of political and economic reform, and in recovering from damage caused by natural disasters, the GDP growth rate in 2018 is projected to be 6.4 percent.[6]

Figure 2: Real GDP growth and sectorial contributions



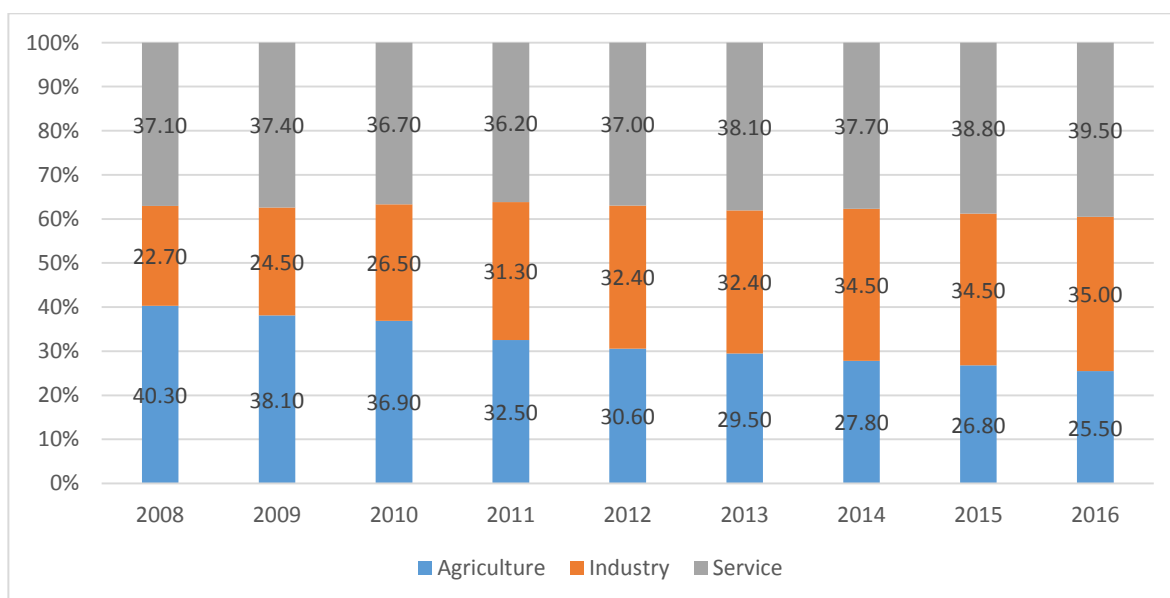
Source: World Development Indicators 2017

The Myanmar economy has been driven by three main sectors (Figure 3). In 2016, the industry sector contributed around 35 percent to the growth in GDP, rising from 22.70 percent in 2008.

Over the same period, the share of the service sector rose from 37 to around 40 percent. The share of GDP from agriculture dropped from 40 percent to slightly above 25 percent over the same period.

The GDP share of agriculture is, on average, 30 percent – 15 per cent less than that of services but 5 percent more than that of the industry sector. The sector also contributes about 61 percent to the national employment figures and between 25-30 percent to the nation’s export totals.[9] The agricultural sub-sector includes crop cultivation, livestock and fisheries.

Figure 3: Share of GDP by sector 2008-2016



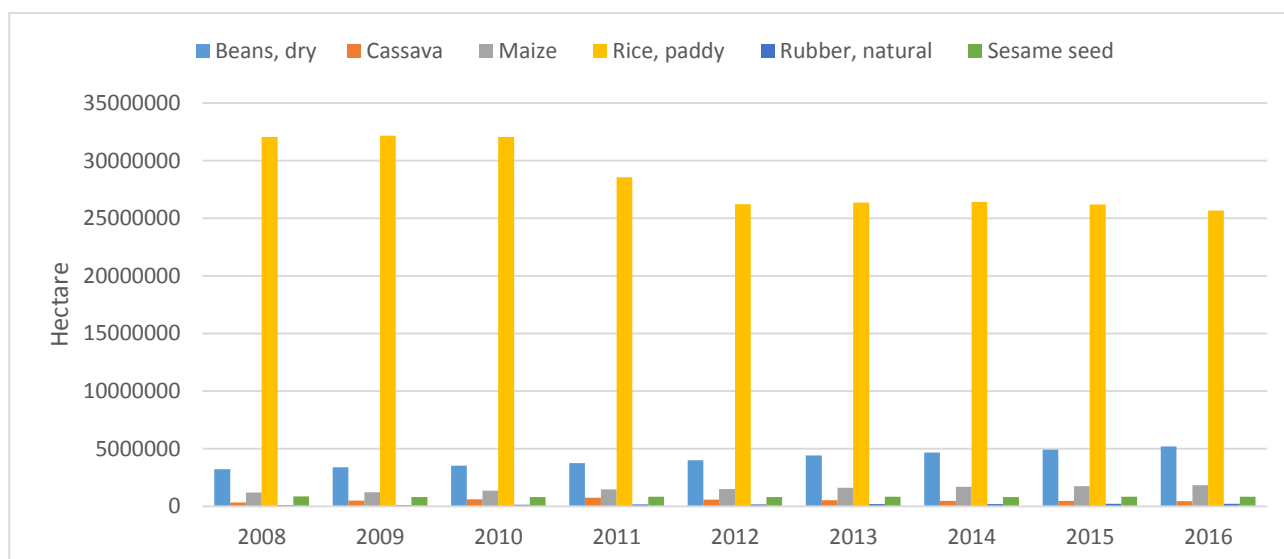
Source: World Development Indicator 2017

Figure 4 shows the cultivated land share by crop. Rice is the major crop. The total cultivated land for paddy was more than 30,000,000 hectare in 2008 before dropping to slightly above 25,000,000 hectare in 2016. The reduction in the area devoted to rice production was countered by a steady increase in areas allocated to emerging commercial crops such as beans, rubber, cassava, and sesame seeds.

Major export crops are rice and pulsesⁱⁱⁱ. At the present, pulses are the leading agriculture export item accounting for USD 1,152 million in 2015/2016. Although rice has historically been the country’s major export, paddy rice production has been declining slightly since 2010, accounting for USD 400-500 million in 2015/16.[9]

ⁱⁱⁱ According to the Food and Agriculture Organization of the UN: “Pulses are a type of leguminous crop that are harvested solely for the dry seed. Dried beans, lentils and peas are the most commonly known and consumed types of pulses.”

Figure 4: Crop Production in Myanmar by tonnes (2008-2016)



Source: FAOSTAT

The country has a huge potential for agricultural development given the richness of its natural resources, the variety of agro-ecological conditions for different types of farm activities, the availability of farm labor, and the abundance of land for farming.[9, 10] There is significant potential for investment in the sector. However, the country has been facing binding constraints in respect of the development of its agricultural sector. The most formidable one is the limited irrigation and supporting infrastructures. Other related constraints are insecure land titles, limited financial resources, farm inputs and extension services, insufficient use of farm mechanization, and low investment in the sector.[9, 10, 11]

Agricultural development in Myanmar is particularly vulnerable to climate change mainly because of the weak mitigation strategies associated with the constraints mentioned above. Given that the majority of the population rely on the farming sector, climate change has negative implication for most of the people.[9, 11]

3.1 Agro-ecological Zones and Climate Change Phenomena

Myanmar has three main agro-ecological zones: the central dry, delta and coastal, and hilly zones.[2, 9] Table 2 shows the characteristics of each zone and their main crops.

The dry zone, is located in the middle of Myanmar and lies between Shan highlands to the east, and Chin Hill and Rakhine Yoma to the west.[5] The population is about 19 million, of whom about 83 percent are engaged in farming.[5, 12, 13] The area is relatively flat with semi-dry weather. Agricultural production is predominantly rain-fed and the major crops are rice and oil crops. Annual rainfall is between 600 mm and 1000 mm. However, cropping in the dry zone is currently being affected by recent climate phenomena.

Observation reveals that there has been a change in climatic conditions in the area such as prolonged drought and shorter rainy periods.[2, 5] Extreme temperatures, erratic rainfall, intense rain and storms, and severe droughts are the main climate hazards affecting the region and these have an impact on the production of major crops such as rice, oil crops and pulses.[5] The limitations in irrigation facilities not only hamper agricultural production in the dry zone but also make it more vulnerable to the changing climate.

With a coastline spanning nearly 3,000 km along the Andaman Sea and Bay of Bengal, the delta and coastal zone is prone to climate hazards such as cyclones, heavy rainfall^{iv}, floods and landfall, all of which are said to have intensified over the last six decades.[2, 5, 14, 15] The delta area (about 50,400km²) is the most populated with 22 million people engaged in farming activities. Production in this region is predominantly rice and fish.[5, 12] The area between Ayeyarwaddy and Sittaung are relatively flat and suitable for rice farming – the major crop produced in the zone, covering more than three million hectare. Some industrial crops such as rubber and oil palm are also present.

The hilly zone, located in the northeastern part of the country, covers four states: Kachin, Kayah, Chin and Shan State. The annual rainfall is between 1,000-2,000mm. The total population is 6.5 million people and 44 percent of all households are engaged in farming activities involving monsoon crops. The area is mountainous and relatively covered by forest, it is also an ‘agricultural frontier’, and shifting cultivation has long been practiced by local people. Food crops such as rice, wheat, maize, sorghum and vegetable are cultivated on a subsistence basis. [12]The hilly terrain, forest clearance and expansion of farmland has caused soil erosion in the area which has, in turn, led to soil degradation. [2, 16]

Table 2: Characteristics of the three main agro-ecological zones

Item	Zone I	Zone II	Zone III
	Central Dry Area	Delta and Coastal Area	Hilly and Mountainous Area
Climate	<ul style="list-style-type: none"> • Summer (Mar to May) • Rainy Season (Mid-May to Oct) • Winter (Nov to Feb) • Annual Rainfall (700 to 1,000 mm) 	<ul style="list-style-type: none"> • Rainy season (Mid-May to Mid-Oct) • Dry season (Mid-Oct to Mid-May) • Annual Rainfall in Delta (2,200 to 28,000 mm) • Annual Rainfall in coastal areas (3,000 to 5,000 mm) 	<ul style="list-style-type: none"> • Rainy season (Mid-May to Mid-Oct) • Dry Season (Mid-Oct to Mid-May) • Annual Rainfall (1,000 to 2,000 mm)

^{iv} Those regions get the highest monsoonal rainfall (generally 5000 mm) in Myanmar.

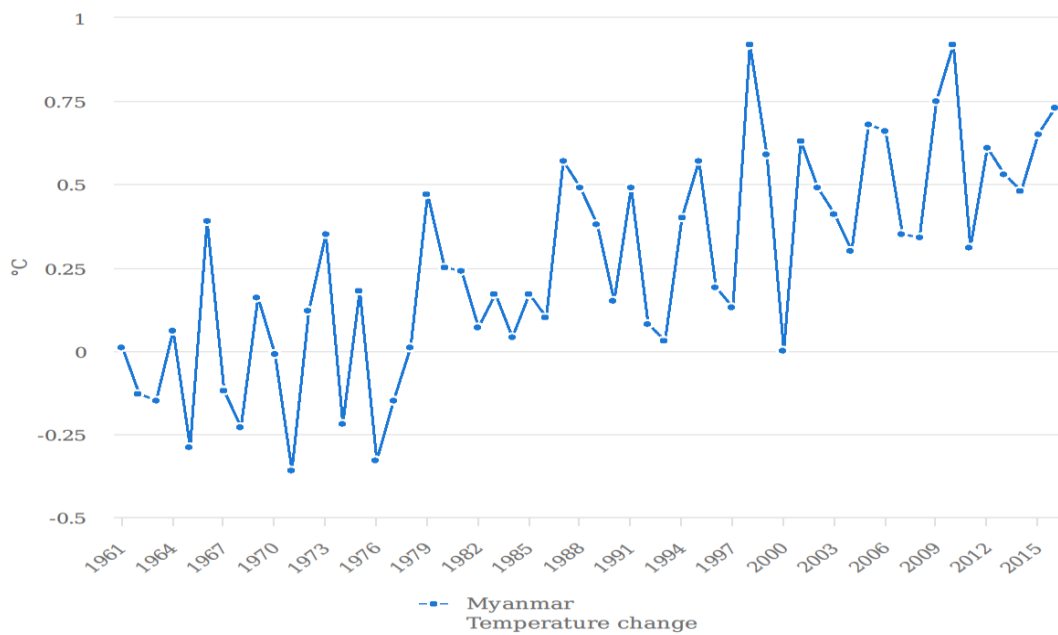
Topography and Land Use	<ul style="list-style-type: none"> • Flat topography, semi-dry to dry conditions • Paddy cultivation fed by irrigation water • Rain-fed paddy lands are found in some areas 	<ul style="list-style-type: none"> • Low land comprises the Ayeyarwaddy delta and Sittaung delta • Area 3.1 million ha, paddy monoculture • Cultivated areas in the coastal regions of Mon, Tanintharyi and Rakhine 	<ul style="list-style-type: none"> • High mountain ranges and forests • Some areas high rainfall, rivers developed • Crop cultivation in valley areas, shift-cultivation in hilly areas
Major Agricultural Crops and practice	<ul style="list-style-type: none"> • Rice, groundnuts, sesame seeds, pulses, oil seeds etc. • Irrigated agriculture and Kaing/Kyun cultivation 	<ul style="list-style-type: none"> • Pulses and rice (60 % of total rice production takes place in the delta zone) • Rice, rubber and palm oil are grown in the coastal zone 	<ul style="list-style-type: none"> • Rice wheat, pulses, maize, sorghum vegetables, sugarcane • Upland crops and fruit trees
Challenges for Agricultural Production	<ul style="list-style-type: none"> • Increasing crop production depends on improving existing irrigation networks and maintenance canals • Sesame production depends on the weather conditions • Rice deficit is observed in some areas 	<ul style="list-style-type: none"> • Improvement and renovation of protection against flooding are required 	<ul style="list-style-type: none"> • Forest land is degraded by shifting cultivation. Soil erosion, sediment and deficit of water resources are found • Few fertile land areas and low potential to manage large-scale farming

Synthesized from: MOALI 2016 and JICA 2013

4. Impact of Climate Change on Agriculture

According to the Germanwatch Global Climate Risk Index 2016, Myanmar was ranked as the second most vulnerable country in the world, and has faced particularly adverse effects of climate change over the past two decades (1995-2014). This is reflected in the limited mitigation and adaptation strategies in the country and its strong reliance on a climate-change prone sector – agriculture.[2] In the last 60 years, the country’s climate has changed significantly.[2] This is evidenced by: (1) an increase in the temperature of around 0.08°C each decade (Figure 5); (2) an increase in total rainfall throughout the country, but a shorter rainy season; (3) the irregular periods of the southwest monsoon season, which has led to late onset and early termination; (4) more frequent extreme weather events such as cyclones, flooding as a result of intense rain, storm surges and drought; and (5) the rising sea-level.[2, 14]

Figure 5: Mean Temperature Changes of Meteorological Years (1961-2015)



Source: FAOSTAT (Jan 12, 2018)

Source: FAOSTAT

In the period 1887 to 2005, 80 out of 1248 tropical storms stemming from the Bay of Bengal, hit the coastline of Myanmar. Recently, in 2006-2010, Myanmar suffered extensively from the impact of three severe cyclones - Mala (2006), Nargic (2008) and Giri (2010) - especially in the Ayeyarwaddy delta and in Rakhine State.[17] The Nargic cyclone of 2008 had a heavy impact not only on people’s lives, but also on agricultural production, destroying 57 percent of the country’s total rice production. The financial loss was estimated at around USD 4 billion, resulting in plunging agricultural growth in the subsequent years before recovery.[2]

From 1910 to 2000, Myanmar was affected by 12 major floods.[17] Flooding from 2001-2015, not only destroyed the country’s transport infrastructure but also damaged agriculture.[17] For example, floods and landslides in 2015 destroyed 20 percent of the country’s cultivated areas (4.2 percent of agricultural GDP), that is equivalent to USD 1.51 billion.[2] During that period the export of rice dropped by 25 percent. [6] The country also suffered frequent droughts during 1980s and 1990s especially in the Central Dry zone, and the severe droughts of 2009 and 2010 destroyed agricultural yields such as rice, peas, tomato and sugar cane.[17]

Later, in 2016, The country suffered the severe El Nino phenomenon, and that resulted in extreme temperatures, severe droughts and unusual rainfall patterns.[18] By 2100, the sea level is predicted to rise approximately 0.56 meters, globally. If this prediction is accurate, the Ayeyarwaddy River would move inland by 10 kilometers and that would significantly affect agriculture, especially rice production. That, in turn, would threaten the country’s food security and result in a drop in revenue from agricultural exports.[2]

All of these events clearly indicate how intensely vulnerable agricultural production in Myanmar is to the impact of climate-related disasters. [2, 19] The climate hazards, and how they impact agriculture in the three main agro-ecological zones, are shown in Table 3.

Table 3: Climate Change Impacts on Agriculture in Myanmar

Climate Hazards	Impacts on Agriculture	Vulnerable Region
Drought	<ul style="list-style-type: none"> • Crop failure and low yields that lead to a decline in workers' productivity, and indirectly increase poverty 	<ul style="list-style-type: none"> • Rain-shadow (arid and semi-arid) central belt • Central dry zone
<ul style="list-style-type: none"> • Cyclones/strong winds • Flood/storm surges 	<ul style="list-style-type: none"> • Damage to rice/crops cultivation, land and infrastructure • Damage to ecosystems and ecosystem services (e.g. mangroves, coastal forests and coral reefs) • Displaced surface and ground freshwater by seawater (saline water) that is indirectly caused by limitations in the supply of irrigation water 	<ul style="list-style-type: none"> • Coastal and delta regions
Intense rains	<ul style="list-style-type: none"> • Intense surface run-off, soil erosion and loss of fertile soil • Crop damage • Inundation by flash floods in lowland areas • The above impacts indirectly cause a loss of valuable farming areas 	<ul style="list-style-type: none"> • Northern hilly region • Mountainous and hilly areas in Kayin, Kachin, Shan, Mon and Chin • Ayeyarwaddy River basin • Coastal areas
Sea level rise	<ul style="list-style-type: none"> • Seawater inundation onto cultivated lands and villages 	<ul style="list-style-type: none"> • Coastal areas, particularly in Rakhine and Ayeyarwaddy

Sources: Synthesised from (1) Myanmar Climate Change Strategy and Action Plan (MCCSAP) 2016-2030, and NAPA 2012

Droughts cause crop failure and a drop in farm productivity. The central dry zone is the most vulnerable in this respect. In Myanmar, 80 percent of rain-fed rice production can be affected by drought and changes in rainfall patterns.[20] The worrying picture is that climatic conditions are changing toward prolonged droughts and shorter rainy periods, and this could further hamper agricultural production in the areas affected.[13]

Coastal and delta regions are prone to cyclones and intense rain that cause flooding. These climate-related disasters not only damage ecosystems, but also agriculture, especially paddy production.[21] Given that the delta is the major area for rice production, and is densely populated, the impact of flood and heavy rain can be said to have a particularly negative impact on the development of the country and its population. Heavy rain and floods caused by cyclones were reported in 2006, 2007, and 2010. Some 1.7 million tons of rice were lost as a result of flooding in 2011, especially in the Ayeyawaddy, Bago, Mon and Rakhine Regions.[17, 20]

Hilly areas have been affected by intense rainfall, causing soil erosion and loss of soil fertility leading to crop damage and an increase in the rate of sedimentation downstream. The area most affected is the northern hilly region. [2] There is, however, insufficient data and information for this paper to comment on the impact of climate change on agricultural production in the hilly region, although this review can confirm that the country's development has been hampered by a series of natural disasters. The literature also claims that the increased frequency of these unfavorable events is linked to global climate change. Ongoing debate has suggested that the mitigation and adaptation strategies are not effective and responsive enough, and that this will consequently result in a significant setback to the country's development.[19] The section below discusses the existing mitigation and adaptation strategies of the country that respond to the mounting impact of climate change.

5. Existing Climate Change Mitigation and Adaptation Strategies

Before the drafting of national climate change policies in 2016, the country had no direct action plans to combat climate change. A number of policy documents were formulated in the early '90s with the aim to protect the environment and preserve natural resources, but these only partly address the need to enhance mitigation and adaptation to climate change. Those documents include the Forest Law Act (1992), the Protected Areas and Forestry Policy Statement (1995), the Environmental Conservation Law (2012) and the Disaster Management Law of 2013. [2, 5, 22]

The country has accepted a number of regional and international conventions and joined related committees such as the IPCC^v, UNFCCC^{vi} in 1992, the Kyoto Protocol in 2003, and the ASEAN Working Group. In parallel with these, a number of policies and projects have been formulated and implemented, including NAPA^{vii} (the document of mitigation and adaptation provided for the government) in 2012, MCCA^{viii} in 2013, MCSA^{ix} in 2015, and MCCSAP^x in 2016 including the draft of the national climate change policy. The aim has been to enhance the country's mitigation and adaptation strategy through knowledge-sharing, capacity building, strategic plans and sectorial priority activities. The prioritized sectors are agriculture and natural resource management.[2, 5, 19, 22, 23, 24] The Ministry of Agriculture, Livestock and Irrigation is implementing several adaptation and mitigation measures such as stress-resistant crop varieties, the adjustment of cropping systems, extended water use and efficiency, improved irrigation efficiency, water and soil

^v Intergovernmental Panel on Climate Change (IPCC)

^{vi} United Nations Framework Convention on Climate Change (UNFCCC)

^{vii} National Adaptation Program for Action (NAPA)

^{viii} Myanmar Climate Change Alliance (MCCA)

^{ix} Myanmar Climate-Smart Agriculture Strategy (MCSA)

^x Myanmar Climate Change Strategy and Action Plan (MCCSAP) [2017-2030](#) is expected to be published soon.

conservation, and measures to reduce emissions from rice fields.[5] These climate-smart responses were introduced to the country’s agricultural development policy in order to achieve climate-resilient productivity and food security.[5] However, information currently available is insufficient to enable this paper to comment on how the program has been implemented and to what extent it has been helping build the mitigation and adaptation capabilities of local people.

The biggest challenge in implementing climate change mitigation and adaptation programs has been the insufficiency of funding support. There are three major sources of funding: (1) the national budget; (2) Foreign Direct Investment; and (3) bilateral and multilateral aid. But these have not been sufficient. [2, 25] Table 4 shows the distribution of bilateral and multilateral spending on climate-related projects between 2013 and 2014. In 2013, total funding was only USD 37million with USD 23 million allocated to mitigation projects, USD 9 million to adaptation projects and USD 5 million to combined adaptation and mitigation projects. The total funding increased more than ten-fold in 2014 when USD 426.7 million alone was spent on adaptation projects. There has been no clear explanation for this sharp increase in financial allocation but it could be the realization among donors of the severity of the impact climate change was having on the development of on Myanmar.

Table 4: Bilateral and multilateral spending on climate-related projects in Myanmar for 2013-2014

Year	2013	2014
Mitigation Projects (US\$ millions)	23	63.9
Adaptation Projects (US\$ millions)	9	426.7
Adaptation and mitigation combined (US\$ millions)	5	27.7
Total funding (US\$ millions)	37	518.3

Source: MCCSAP

6. Conclusion

The impact of climate change on the development of Myanmar is undeniable. The review of secondary data in this paper confirms the change in the country’s climatic parameters such as the increasing temperature, prolonged drought, more frequent floods and intense rainfall, and delayed rainy seasons. All of these are linked to the changing global climate. The largely rain-fed agriculture of the country has been depending on favorable climate conditions to achieve good productivity. Thus, the changing and unpredictable climatic conditions pose an increasing threat to agricultural production as well as to economic development as a whole. The data confirms the strong correlation of agricultural growth to the overall GDP. As agriculture accounts for the largest share of national employment, setbacks in agriculture due to climate related disasters can affect a large proportion of the country’s population. The increased frequency of floods caused by a series of cyclone was responsible for losses amounting to billions of dollars in respect of lost farm

production, particularly rice cultivation in the delta region, while the prolonged droughts have hampered farm production in the dry zone. The scale and intensity of the impacts of climate change suggest that the country needs responsive and well-developed mitigation and adaptation strategies in order to minimize vulnerability.

This study cannot evaluate the efficiency and the effectiveness of previous programs in respect of climate change due to a lack of data. But it can capture some challenges with regard to program implementation, and those are the lack of budget spending on resilience programs and a limited technical capacity. There is a need to scale-up budget allocation for projects/programs relating to mitigation and adaptation. Until now, the national policy for tackling climate change is still in draft form. Mitigation and adaptation strategies have been mainstreamed to related sectoral policy. This means that the previous program interventions have been undertaken without the guidance of a single holistic policy framework. Hence, finalizing the national climate change policy should be considered a top priority.

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