A review of food security and flood risk dynamics in central dry zone area of Myanmar

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Abstract

The Central Dry Zone area of Myanmar is the most water stressed and one of the most food insecure regions in the country. Agriculture is the most important economic sector in Myanmar as it is essential for national food security and a major source of livelihood. The adverse effects of climate change are believed to be a major constraint to food insecurity and flood risk. This paper gives a structured overview of the current scientific knowledge available and reveals the relevance of this information with regard to food security and flood risk dynamics in central dry zone area of Myanmar.

Keywords: Food security; flood risk; remote sensing; dry zone, Myanmar

1. Introduction

In Myanmar, 44 percent of households had problems meeting food needs [1] despite being part of a major agricultural region [2]. According to [2], 58% of those living in the region are farmers and 25% are farm laborers. Similarly, other studies [3] also indicate that farming and casual labor in the agriculture sector are the two key livelihood activities in the Dry Zone [4]. The vulnerabilities of many farming communities are increasingly complex as Myanmar undergoes unprecedented political, social, and environmental changes, making the design of impactful development interventions challenging.
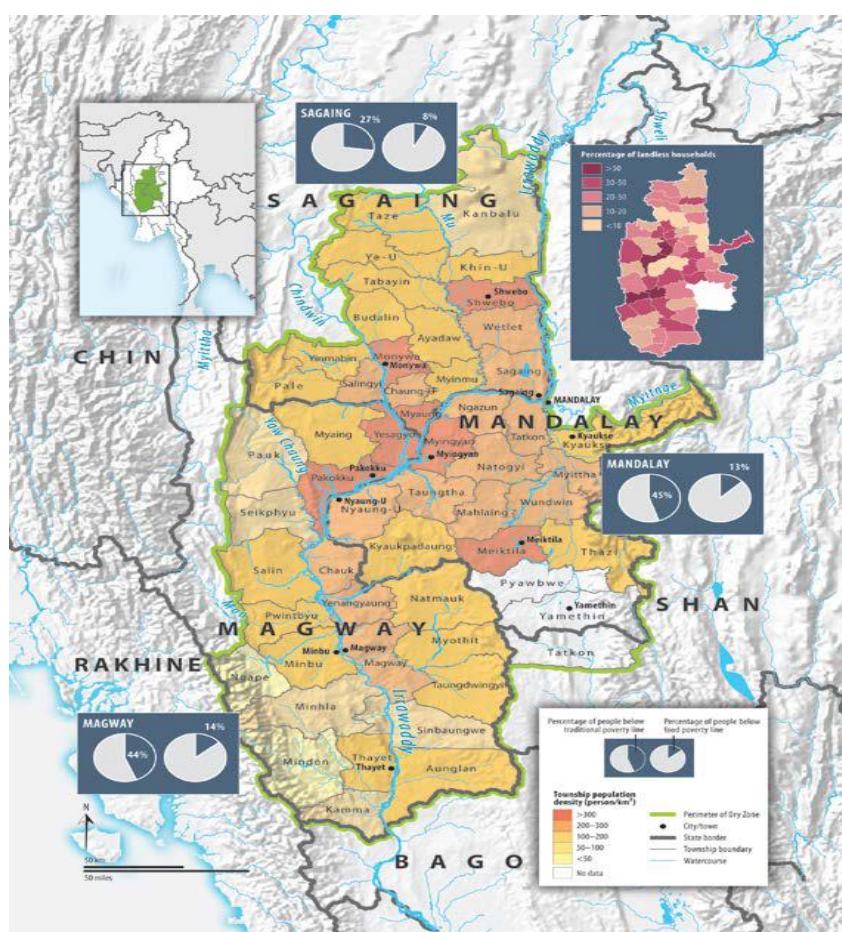

Fig. 1. The demographics of Myanmar's Dry Zone, showing the population density of townships and distribution of landless households. (Source: Boundary/townships as defined by the Myanmar Information Management Unit [MIMU] [Map Id.: MIMU983V01], March 2013 [www.themimu.info/]; Statistics on population density, poverty and landless households from JICA 2010).

Food insecurity and flood risk are very common in the Dry Zone (Fig. 1). A survey conducted by [5] found that 18% of households had inadequate food for consumption and more than a quarter of children under the age of five were underweight. Households with poor access to land and markets and those relying on casual labor are the most likely to have insufficient food. Farming households are more likely to be food-secure, but food security is precarious even for these families. In 2010, the food security of 41% of farming households was adversely affected by dry spells [6].

2. Climate features

Mean annual rainfall in the Dry Zone ranges from 500 to 1,000 mm. This is low compared to the 2,000-5,000 mm range received by the rest of the country (Fig. 2). Temperatures commonly reach 40 °C in the dry season. The water collected for use in villages (excluding irrigation), about 15-20% was allocated for drinking purposes, about 50% for other domestic uses and 30-40% for livestock watering. The Dry Zone is the only truly semi-arid area of Southeast Asia; annually, rates of evaporation are more than double those of rainfall. The wet season, coinciding with the southwest monsoon, lasts from May to October. The dry season is divided into winter (between November and February) and summer (from March to April).
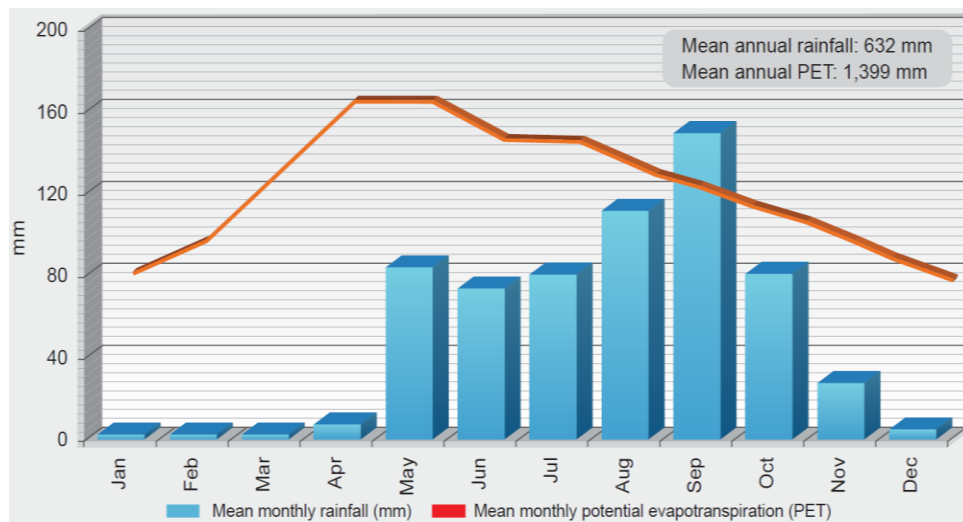

Fig. 2. Mean monthly rainfall and potential evapotranspiration (PET) at Pakokku, close to the center of Myanmar`s Dry Zone (Source: FAO LocClim: Local Climate Estimator [http://www.fao.org/nr/climpag/pub/en0201_en.asp]).

2.1. Cyclones

The adverse effects of climate change on agriculture in the Ayeyarwady Delta and Costal Regions are higher temperature, changing rainfall pattern and subsequent flow regime and sea-level rise [7]. Before 2000, cyclones made landfall (i.e. the center of the storm moved across the coast) along Myanmar's coast once every three years. Since the turn of the century, cyclones have made landfall along Myanmar's coastline every year. From 1887 to 2005, 1,248 tropical storms formed at the Bay of Bengal. Eighty of these storms (6.4% of the total) reached Myanmar's coastline. Recent strong cyclones include Cyclone Mala (2006), Nargis (2008) and Giri (2010).

2.2. Scares rainfall and droughts

Normally, annual rainfall is 29.5 inches (40 inches–19 inches) and rainy days range from 62–41 days per year (2000-2015) and 21% of the Dry Zone townships (54 townships) were affected by drought every year [8]. Likewise, the probability of drought occurring in any given township is once every five years [9].

According to the characteristics of identified droughts using rainfall series, the worse drought that hit the area was during 1979 and 1980 [10]. The second worse drought that hit lower Sagaing and Mandalay took place during 1982 and 1983. The third worse drought that hit the whole area of Dry Zone was during 1993 and 1994 [11]. Except for the interval between the second and third worst droughts of some 10 years, recurrence of droughts in the Dry Zone region seems to be showing up at shorter intervals of approximately three years [12].

2.3. Heavy rains and floods

Floods can represent a basic asset for people's well-being, income and cultures but also a drawback for societal and economic development. Myanmar is regularly affected by severe floods comprising river floods, flash floods, pluvial floods and coastal floods. Catastrophic flash floods associated with high rainfall occurred in the central dry zone, e.g. in the year 2011 [7]. Just recently, the western part of the country was affected by very heavy monsoon rains in August 2015. Particularly, the Ayeyarwady delta zone and the central dry zone are extremely vulnerable to impacts from floods due to associated crop loss and the relatively dense population. In hilly and mountainous rural areas, heavy rainfalls often trigger disastrous landslides, with

severe consequences for the Burmese people, who normally live in small wooden huts. The flood risk of Myanmar is assessed as very high due to high vulnerability and low capacity to cope with floods. For the future, the frequency of 100-year floods in Myanmar is likely to increase [4].

3. Land use/cover scenario

3.1. Data

To know the land use/cover scenario in the study are we used primary (satellite data) and secondary data such as ground truth for land use/cover classes and topographic sheets. The ground truth data were collected using Global Positioning System (GPS) for the year of 2016 in the month of June to August for image analysis and classification accuracy. A selection of multisensor, multi-resolution and multi-temporal images was used in this study. The specific satellite images used were Landsat TM (Thematic Mapper) for 1985, 1995, ETM+ (Enhanced Thematic Mapper plus) for 2005, Landsat OLI (Operational Land Imager) for 2016, an image captured by a different type of sensors [13].

3.2. Image processing

Digital image processing was manipulated by the ArcGIS software. The scenes were selected to be geometrically corrected, calibrated and removed from their dropouts. Other image enhancement techniques like histogram equalization were also performed on each image for improving the quality of the image. Digital topographical maps, 1:50,000 scale, were used for image geo-referencing for the land use/cover map and for increased accuracy of the overall assessment. At this stage, 20 points were selected as GCPs (Ground Control Point) for all images. Data sources used for the GCP selection were: digital topographic maps, GPS (Global Positioning System) acquisitions. Then, all four images were geometrically corrected up to ortho-rectified level. The data of ground truth were adapted for each single classifier produced by its spectral signatures for producing series of classification maps [14].
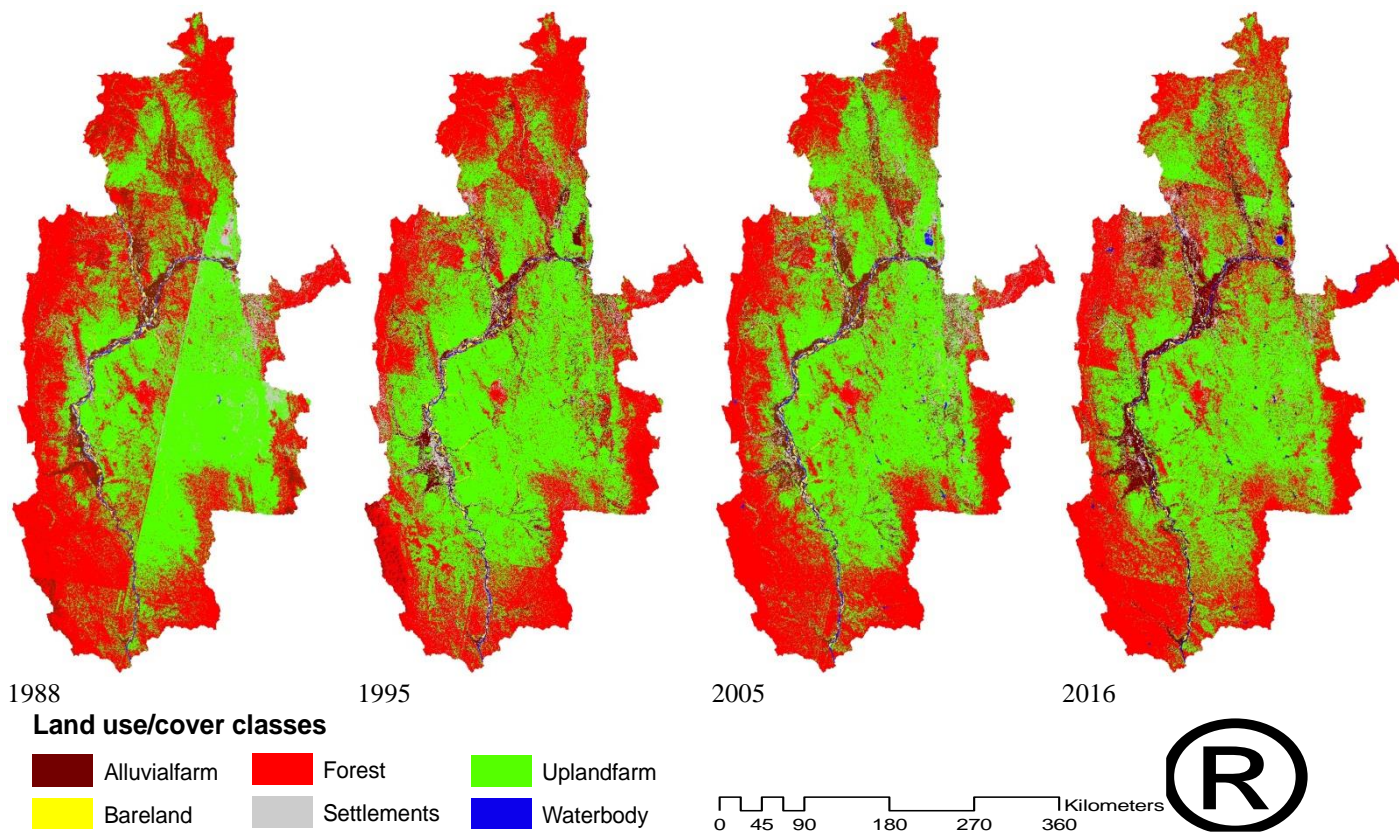
3.3. Classification of Images

Fig. 3. Land use/cover maps from 1988 to 2016 for central dry zone area of Myanmar.

After preprocessing, first use unsupervised classification and get maximum possible classes on the basis of gray levels. Then used supervised classification method with maximum likelihood algorithm in ArcGIS Software. Maximum likelihood algorithm (MLC) is one of the most popular supervised classification methods used with remote sensing image data. This method is based on the probability that a pixel belongs to a particular class. Ground verification was done for doubtful areas. Based on the ground trothing, the misclassified areas were corrected using recode option in ArcGIS [15]. The error matrix and Kappa

methods were used to assess the mapping accuracy. Six land use/cover types were identified in the study area viz., (i) Alluvial farm (ii) Bare land (iii) Forest (iv) Settlements (V) Up-land farm (Vi) Waterbody.

3.4. Land use/cover change detection and analysis

Figure 3 shows land use/cover image after supervised classification. These images provide pattern of land use/cover of the study area. The gray color represent settlements, dark brow alluvial farm, red color forest, blue color water, yellow color shows the bare land and green color shows up-land farm. All land cover class maps were compared with reference data, which was prepared by ground truth, sample points and google earth. Over all classification accuracy of the study area was more than 90% for all four dates.

Table 1. Land use/cover area from 1988 to 2016 for central dry zone area of Myanmar

	1988		1995		2005		2016	
Class	Area KmSq	%	Area KmSq	%	Area KmSq	%	Area KmSq	%
Alluvialfarm	3982.84	4.91	5084.54	6.27	5577.87	6.88	5728.17	7.06
Bareland	590.18	0.73	695.92	0.86	614.90	0.76	489.60	0.60
Forest	38509.03	47.48	32680.14	40.29	34640.82	42.71	34863.05	42.98
Settlements	3226.57	3.98	3555.73	4.38	4329.77	5.34	4836.39	5.96
Uplandfarm	34161.41	42.12	38547.31	47.52	35089.19	43.26	34423.78	42.44
Waterbody	643.99	0.79	550.38	0.68	861.45	1.06	773.00	0.95
Total	81114.00	100.00	81114.00	100.00	81114.00	100.00	81114.00	100.00

In dry zone area the major change was in alluvial farm which was increased from 4.91% to 7.06% (table 1). This is the area where during monsoon season area was flooded and later on dry so local people used this land for agriculture purpose (fig. 3). Upland farm was also increase from 1988 to 1995 from 42.12% to 47.52% and later on stable around 43% of the total area. Forest area was reduced in fast half from 47% to 40% and later on stable on 42% by governmental protection. Settlements area has been continuously increasing from 3.98% to 5.96% (table 1). Over all unstable agriculture (alluvial farm) area has been increasing due to increased population, food requirement and market demand.

Table 2 Cross table of land use/cover classes from 1988 to 2016 for central dry zone area of Myanmar

1988-95	CLASS	ALLUVIALFA	BARELAND	FOREST	SETTLEMENT	UPLANDFARM	WATERBODY	Total
	Alluvialfarm	1367.46	43.94	1298.96	585.50	638.49	33.60	3967.96
	Bareland	72.38	271.42	14.22	51.70	90.47	86.60	586.79
	Forest	1823.71	43.94	24461.78	1717.73	10566.16	71.42	38684.75
	Settlements	683.73	72.38	986.17	566.11	877.60	46.53	3232.53
	Uplandfarm	1120.59	109.86	5893.78	501.49	26360.94	11.63	33998.30
	Waterbody	52.99	137.00	16.80	71.09	14.22	351.56	643.66
	Total	5120.87	678.56	32671.72	3493.62	38547.89	601.35	81114.00
1995-05	CLASS	ALLUVIALFA	BARELAND	FOREST	SETTLEMENT	UPLANDFARM	WATERBODY	Total
	Alluvialfarm	1971.33	77.55	1043.00	841.38	1070.14	129.24	5132.64
	Bareland	86.59	249.44	6.46	85.30	137.00	116.32	681.12
	Forest	1832.68	11.63	24111.79	1416.52	5178.81	74.96	32626.40
	Settlements	749.62	62.04	1080.48	1027.49	484.67	99.52	3503.81
	Uplandfarm	1001.64	105.98	8377.61	853.01	28190.74	76.25	38605.23
	Waterbody	23.26	105.98	9.05	56.87	7.75	361.88	564.80
	Total	5665.13	612.62	34628.39	4280.57	35069.11	858.18	81114.00
2005-16	CLASS	ALLUVIALFA	BARELAND	FOREST	SETTLEMENT	UPLANDFARM	WATERBODY	Total
	Alluvialfarm	2464.60	45.23	1406.86	567.36	1132.14	64.62	5680.81
	Bareland	133.12	180.94	6.46	36.19	160.26	86.59	603.55
	Forest	1028.75	6.46	25488.61	1002.58	7059.38	52.99	34638.76
	Settlements	836.18	51.70	1169.62	1330.85	822.28	96.93	4307.55
	Uplandfarm	1093.37	54.28	6879.42	1646.20	25323.49	28.43	35025.18
	Waterbody	95.64	121.49	40.06	50.40	52.99	497.57	858.15
	Total	5651.64	460.09	34991.02	4633.57	34550.54	827.13	81114.00

Table 2 show 1367.46 km^2 area was stable but major area come in this class from forest and up-land farm from 1988 to 2016. It means during monsoon season these forest and up-land farms were under flood and later on in dry time local people use this area for alluvial farming to complete food demand. Settlement area have been increasing continuously but from 1988 to 2005 its increase in alluvial farm and up-land farm as booth areas used for agriculture purpose so farmers and labors use there agriculture field for accommodation purpose because this is convenient for them. But from 2005 to 2016 forest area was encroached by

settlements around 1002 km^2 forest area convert in settlements. In all three decade major forest area encroached by upland farm, it`s show pressure of food demand on agriculture area due to increased population and market demand (table 2).

4. Food security and flood risk

Farming communities in the Dry Zone were found to be most sensitive to the impacts of erratic rain, land degradation, poor access to quality inputs, and unsupportive agricultural policies. In 2014, the country-wide remote sensing data of the main (wet) season rice crop, which contributes 80% of the annual production, indicated that the central and southeastern parts of the country had low soil moisture and remained below the average level. In 2011-2012, Myanmar's rice area was 7.59 million hectares and total production was 29.01 million metric tons. In 2014/15, the Food and Agriculture Organization of the United Nations (FAO) tentatively forecasts that the aggregate rice production will increase by 4% from last year but still remains below the average level. Agriculture and crop production in Myanmar are strongly affected by rainfall pattern as crop cultivation is mostly rainfed. The irrigated area of agricultural land in Myanmar increased from 12% in 1987-1988 to18% in 2006-2007.

Myanmar is self-sufficient in food production at the national level. However, food insecurity and flood risk exists at the household level in some areas due to low income, constraints in food production, transportation, poor knowledge in feeding practices, poor caregiving, regular loss from floods and droughts. Myanmar's food and agriculture systems—including livestock and fisheries—determine the quantity, quality and diversity of food available for consumption. Therefore, food security and flood risk should focus on availability, accessibility, utility, stability and climate change.

Fig 4. Study area photographs during ground truth and field verification in central dry zone area of Myanmar.

In 2011, the government launched a National Strategy on Rural Development and Poverty Alleviation focusing on eight priority areas, most of which are related with agriculture and rural sector, namely: 1) agriculture production; 2) livestock and fisheries production; 3) rural productivity and cottage industry; 4) micro savings and credit enterprises; 5) rural cooperatives; 6) rural socio economy; 7) rural renewable energy; and 8) environmental conservation.

The first of the eight Millennium Development Goals (MDG) set in 1996 is to reduce poverty by half by 2015. In line with this, Myanmar is striving to attain this MDG goal by reducing current poverty level of 26% to 16% by 2015.

More specifically, the following measures have been implemented in Myanmar to improve agricultural productivity and ensure food security:

➢ The Government **implemented 129 irrigation projects** between 1988 and 2002. These include the Thaphanseik Dam which is one of the largest dams in Southeast Asia.
➢ In the **Central Dry Zone**, varieties of crops are cultivated using crop intensification farming systems: i) mixed/multiple cropping systems i.e. two or more crops in the same field to improve soil fertility, increase crop yield and act as

insurance against crop failure; and ii) sequential cropping systems i.e. two or more crops in a time sequence in a year to reduce intercrop competition.

➢ In the **Ayeyarwady Delta,** a range of rice varieties have been introduced for cultivation including traditional quality, salttolerant, deep-water, waterlogged and submerged rice varieties.

4.1. Alluvial farming

Alluvial farming can be seen as a good example for food security in flood risk area in the dry zone of Myanmar (Fig. 4). Lower rainfall amounts or dry periods result in lower river discharge and foster the accumulation of sandbars in the river bed. Moreover, land use changes and forest logging have an additional influence on sedimentation loads in the river and create new fertile floodplains. Most likely, these processes have a visible impact on alluvial farming in the dry zone because more fertile arable land with good access to irrigation water is available. This is of even higher importance in the light of an increase in dry spells and changed timing of the monsoon rain in the dry zone. Our land use/cover analysis shows an increase in alluvial farming by 1745.33 km^2 since 1988 (table 2). Most of the alluvial farmers grow crops like onions because of market prices, suitability to alluvial land and short-term benefits (personal communication with citizens of the dry zone). Concurrently, small-scale alluvial farming implies a potentially higher flood risk and related crop failure and loss of yields for the farmers and livelihoods of their families and communities.

5. Conclusion

The Dry Zone faces two main challenges relating to water: reliable supply of safe water for drinking and domestic purposes; and access to water to sustainably increase agricultural production, food security and flood risk. Three main strategies are being used to manage variability: rainwater harvesting and storage in small multi-purpose reservoirs; accessing groundwater through dug wells and tube wells for domestic and livestock uses and increasingly for supplemental irrigation and formal irrigation schemes. The experiences of other developing agricultural economies indicate that improving water management is an important first step to increasing smallholder production. Better water management reduces the risk of crop failure, allows for cultivation of a second crop and enables farmers to invest in improved crop varieties and fertilizers. With less than 16% of the cultivated land presently irrigated, increasing the productivity of rainfed agricultural systems will be key to achieving food security, raising incomes and improving livelihoods even in flood risk conditions.

Acknowledgements

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