PHYSIO-CLIMATIC CLASSIFICATION OF BANGLADESH'S RICE PADDY FIELD FOR ALTERNATE WETTING AND DRYING (AWD)

Md Rahedul Islam and Wataru Takeuchi
Institute of Industrial Science, The University of Tokyo, 4-6-1 Komaba, Meguro-ku, Tokyo, 153-8505, Japan
Email: rahe@g.ecc.u-tokyo.ac.jp; wataru@iis.u-tokyo.ac.jp

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ABSTRACT: Alternate wetting and drying (AWD) irrigation system are a water saving, methane emission reducer and cost benefited for rice production. Suitability assessment studies provides the opportunities and limitations to the stakeholders for proper planning. To accelerate the AWD irrigation system, the suitable area and season is very important for the maximum output of AWD irrigation system. The objective of this study was to classify the rice area of Bangladesh for AWD suitability in terms of physio-climatic parameter, and to evaluate the spatiotemporal suitability of AWD irrigation system. The methodology adopted combines physical parameters; slope, soil texture, moisture, drainage, permeability, PH, and the climatic parameters, rainfall and temperature that affect AWD suitability. The geospatial data of soil properties have been collected, interpolate, reclassify, rasterized and scored according to the importance for suitability. The Remotes sensing data of AW3D30 for slope, Terr climate for temperature and GSMaP for effective precipitation have been processed, reclassified and scored for suitability. Further, the weighted overlay method has been applied to significance weights of different controlling parameters for assessing suitable land and time for AWD rice irrigation system in the study area. The result shows that, 38.82%, 59.45%, 1.35% and 0.37% of rice cultivated are respectively highly, moderately, low and very low suitable based on the physical properties. Based on the physio-climatic parameter, 81.20% of Boro rice area are highly suitable, whereas 0% and 0.07% of Aus and Amon rice area are highly suitable for AWD. Different scenario based AWD irrigation application water save and methane emission reduction have been evaluated. To accelerate the AWD irrigation implementation rate, this study will help the policy makers as well as the farmers for the efficient and fruitful application of AWD.

1. INTRODUCTION

Rice is the staple food more than half of the world population. In Bangladesh, rice is the staple food (70% of calories) and the 4th most per capita rice consuming (475gm per day) country in the world (FAO, 2015 & Majumder et al. 2016). The 75% of the total arable land of the country used for rice cultivation. The country's rice producing area was 10.45 million hectares in 2001 and 11.45 million hectares in 2018 (Islam & Takeuchi, 2019). However, the rice production of the country is not enough and frequently need to import rice to meet the food demand of the people. Due to the drastic population growth (98 billion) growth need 70% more food (FAOSTAT, 2015) in 2050. The country trying to increase the rice production in future decade to ensure the food security.

The rice production of the country facing several challenges; i) the arable land losses: the country is losing agricultural land due to increasing demand for residential and industrial use at the rate of 1% of total arable land (Hasan et al., 2013). ii) Climate change impacts: Bangladesh is one of the most climatic risk vulnerable country in the world and due to the climate change impacts (global warming, sea level rising, extreme weather event), the country frequently facing natural calamities like flood, cyclone, sea level rising, salinity intrusion etc. The rice cultivated areas of Bangladesh is located low-land, flat and inundate areas and these areas are easily damaged by natural disaster likes floods, drought and storms. Moreover, Agriculture sector is the largest GHG's producer (39%) and rice is the account for 24% of total agriculture emission, 13% of country's total GHG's emission (*WRI CAIT 2.0, 2015*). Based on IPCC method the country's GHG's emission from rice paddy filed was 1196 Gg/year in 2001 and 1339 Gg/year in 2018. iii) Water Scarcity: Traditionally, rice is cultivated under fully flooded condition during the entire growing period, which required huge amount of water (3000-35000 liter/kg). Annually, the country withdraws 31.34 km3 water for irrigation and 79% of the water source is ground water (FAOSTAT, 2015). The country irrigation practices development leads green revolution and increased food production drastically. The Irrigation developments and yield improvement have been sustained by the construction of surface water use and shallow and deep tube-well irrigation pump also increased from 0.2 million to 10 million from 1985 to 2012. Due to the excessive ground water pumping, the ground water table decreasing 2-3 feet/year over the country (Hassan *et al*. 2013).

The rice cultivation has great socio-economic impacts for the country. But, the rice production of the country is under great socio-economic and environmental threat. The more rice production means use more precious ground water and produce more GHG's methane, which accelerating the global warming. The country is committed to reduce GHG's as part of the global agreement on climate change adopted by the United Nations Framework Convention on Climate Change (UNFCCC). With the conclusion of COP 22, the "COP of Action", country is now seeking practical innovations and solutions to meet both their mitigation commitments and food security goals (Nash J., 2016).

Alternate Wetting and Drying (AWD) irrigation system are one of the sustainable solutions for rice cultivation. AWD, is a management practice in irrigated rice characterized by periodic drying and flooding of fields. Submergence of soil and organic residual material in rice paddies leads to anaerobic decomposition of organic matter that releases methane. Periodic drying events interrupt the duration of this process and reduce methane emissions up to a 70% compared to continuous flooding (B. R. K. Runkle *et al., 2019*). In addition, AWD can reduce water use by up to 30% without any production loss, thus also resulting in water conservation and reduced fuel consumption required for water pumping (Bsak R. 2016, Carrijo *et al.*,2018).

In Bangladesh, AWD irrigation system have been introduced in 2010 by international rice research institute (IRRI). Although the national and international organization working on dissimilation of AWD irrigation system, but the AWD irrigation system has not been widely applied by farmers in the field level. The widespread uptake of AWD will need support from a range of different stakeholders, namely irrigation authorities, extension services and local government units, to demonstrate the benefits and viability to farmers and to adapt the way in which water is provided, managed and valued. The AWD suitability analysis have not pay much attention to adopt and upscaled AWD irrigation system. The climatic variable soil percolation rate, rainfall and filed data applied for AWD suitability analysis in Philippine (Sander *et al.*,2017). However, the local climatic condition, physical features determined the suitable area for AWD irrigation. The physical, and climatic parameter with geospatial techniques for AWD irrigation suitable rice area makes this study noble.

To adopt the AWD irrigation system at field level, the proper information on AWD irrigation is very important. In this study, we used an empirical method to asses the suitable area for AWD irrigation application based on physical and climatic parameters. The objectives of this study are,

(i) To mapping the rice and irrigated rice area from 2001-2018
(ii) To assess the physio-climatic suitable area for AWD rice irrigation,
(iii) To evaluate the AWD suitable rice area with relevant field data.

2. METHODOLOGY

This study consist of (1) rice and non-rice area mapping with spectral similarities of MODIS NDVI data over Bangladesh; (2) AWD suitable rice area mapping with geospatial and remote sensing based physio-climatic parameters in Bangladesh; (3) sensitivity analysis of the AWD suitable parameter and classes; (4) Evaluate the AWD suitable classes with the relevant field data. A flowchart of this study is illustrated in Figure 1.

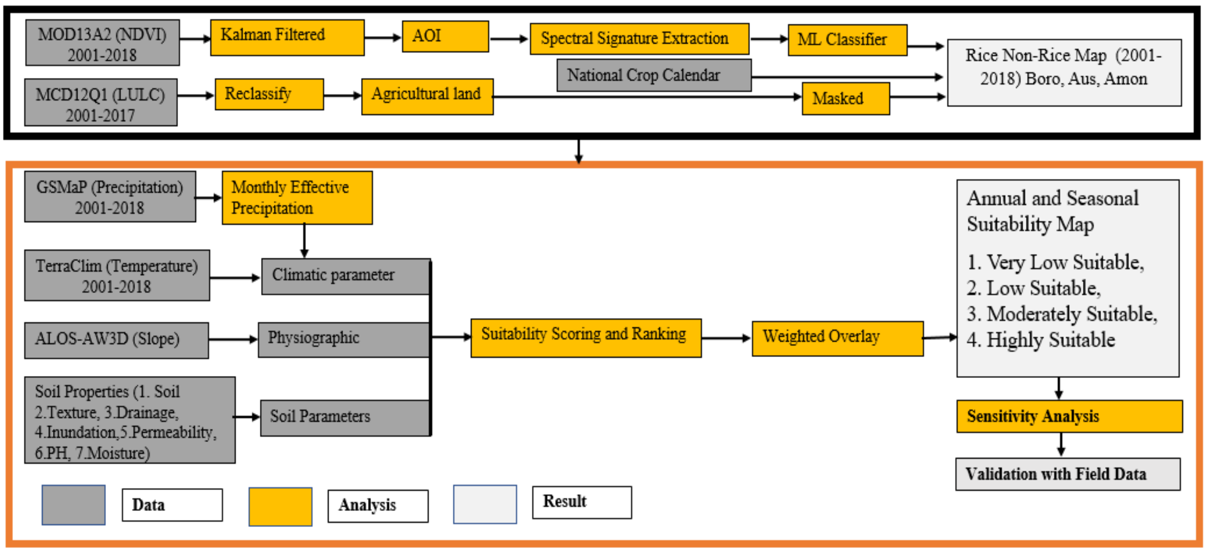

Figure 1: The overall flowchart of this study

2.1 Study Area

Historically, Bangladesh is an agrarian country. Agriculture contributes 19.2% of total GDP and 40% of labor force engaged in this sector (BBS, 2018). About 60% of the land area are arable and 80% of arable land used for rice production. The mega river basin and favorable climatic condition play an important role to supporting the agricultural activities over the country. The rice is cultivated all over the country as single double and triple crop. The climatic condition has a great impact on the agriculture especially the rice cultivation. There is a huge seasonal variation of the weather parameter especially the temperature and rainfall (figure 2). Average annual rainfall varies from 1,200 mm in the extreme west to over 4,000mm in the northeast and temperature 4º C in January to 42º C in April (BMD, 2018). The country's mean annual lake evaporation is approximately 1040 mm, which is about 45 percent of the mean annual rainfall (Kirby *et al.,* 2014). There are three main rice growing season in the country; i) Boro rice season, which planted in January/December and harvested in March/April. The entire growing period of the Boro rice season is almost rainless; ii) Aus rice planted in April /May and harvested in July/August and iii) Amon rice season (July/August to November) are the wet season and almost 80% of total rainfall occurred during this period. In figure 1 illustrate the geographical location, generalized land use and land cover types of the country. The dry season Boro rice area and production gradually increasing. Due to the rainless dry season the Boro rice season fully depended on irrigation. The wet season Aus and Amon rice also need supplementary irrigation. But, most recently due to the climate change and human intervention, the upper flow of the river is dried up in summer and flooded in the rainy season. As a result, the surface water flow and water reservoir of the country drastically decreased. The experts predicted that the country will face a great challenge to produce rice in future decades.

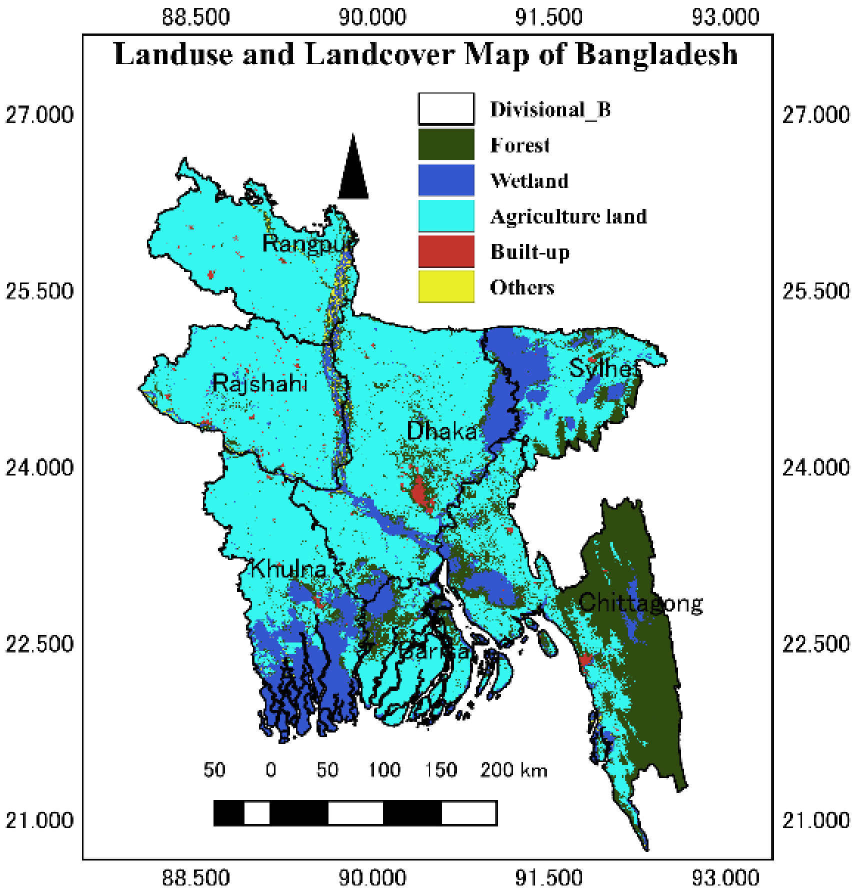

Figure 1: Gneralized land use and land cover map of Bangladesh

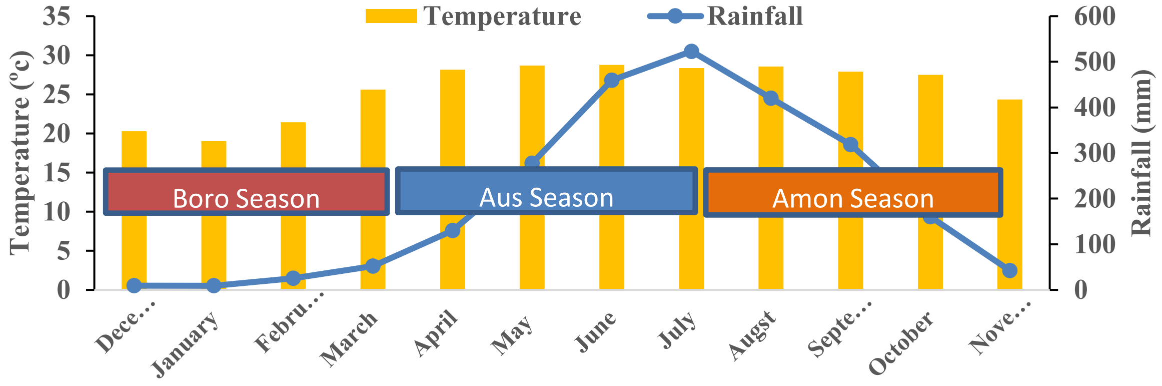

Figure 2. Monthly temperature and rainfall distribution of the country associated with major rice paddy cultivation season over the Bangladesh.

2.2 Data Used in this Study

Several data set have been used for this study. Remote sensing data for rice area mapped from MOD16A2 data, land use and land cover map from MCD12Q1, effective precipitation from GSMaP, monthly temperature from Terra Climate, and AW3D30m data for slope analysis have been used for this study. Besides the remote sensing data, GIS based shapefile data of different soil properties like texture, drainage, inundation, p^H, permeability has been used. The annual rice crop calendar map, Bangladesh dominant crop map have been used as supplementary GIS data. The AWD irrigated rice paddy field and water use data have been collected from Rural Development Academy (RDA). The auxiliary and validation data on rice area, irrigated rice area, evapotranspiration, precipitation have been collected from Bangladesh Agricultural Research Council (BARC), Bangladesh Meteorological Department (BMD), Bangladesh Bureau of Statistics (BBS), Bangladesh Rice Research Institute (BRRI), CSIRO, FAOSTAT, and relevant literature review from journal and publications. The source, spatial and temporal resolution, purposed of the data shown in table 1.

Table 1: Dataset used of this study

Dataset	Product	Spatial Resolution	Temporal Resolution	Purpose
MOD13A2	NDVI	500m	16 days (2001-2018)	Rice Mapping
MCD12Q1	LULC	500m	Annual (2001-2017)	LULC
MOD16A2	ET	500m	8 days (2001-2018)	ET
GSMaP	Precipitation	0.1 degree,	Monthly (2001-2018)	Precipitation
Terra Climate	Temperature	1km	Monthly (2001-2018)	Temperature
JAXA-ALOS	AW3D	30m	-	Slope
Soil Properties	Texture, Drainage, p^H, Permeability, Inundation	1km	1998	-
AWD Field Data	Water use and save	-	2018	AWD Suitability Assessment

2.3 Rice Area Mapping

Moderate Resolution Imaging Spectrometer (MODIS) MOD13A2 1km spatial resolution, 16-day temporal resolution, and atmospheric corrected normalized difference vegetation index (NDVI) dataset on Bangladesh from 2001-2018 (Didan *et al.* 2015). MOD13A2 applies a simple bidirectional reflectance distribution function (BRDF) model and an angular compositing method to minimize angle effects and BRDF-related issues (Huete *et al.*,199). In Bangladesh, the most challenging to use optical data is seasonal uncertainty specially cloud contamination, missing values and atmospheric noise. We use Kalman filter (KF), is a recursive extrapolation algorithm that integrates observations and their respective uncertainties to estimate the state of a process minimizing the mean of the squared errors (Bishop *et al.,* 2004) To avoid the challenge, we used maximum and minimum NDVI values for Kalman's filtering and smoothing. The Kalman filters makes the NDVI time series smooth and continuous time series of NDVI values from 2001-2018. In figure 3 shows the MOD_NDVI spectral signature with Kalman filter and without Kalman filter. We prepared annual MOD_NDVI data layer from 16-days composite.

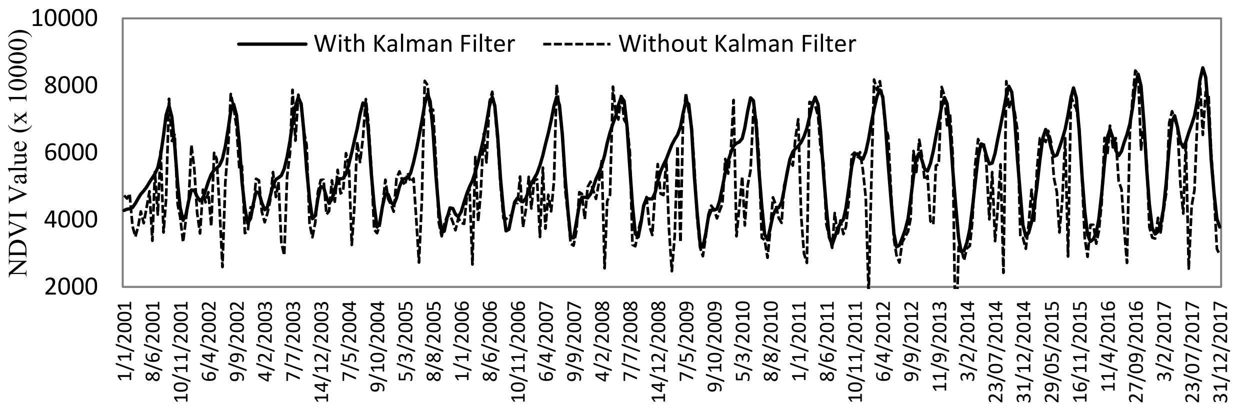

Figure 3. MOD_NDVI Values spectral signature with and without Kalman filter.

MODIS tera and aqua combined MCD12Q1 500m spatial resolution land use and land cover (LULC) data with the international geosphere-biosphere program (IGBP) classification data resampled and reclassified as agricultural land, water body, barren land, infrastructural land and forest area. The agricultural land area extracted from reclassified MCD12Q1 and masked out from MOD_NDVI annual data to reduce the data volume and prepared annual agricultural land MOD_NDVI data layer from 2001-2018. The NDVI spectral signature of annual Kalman filtered agriculture shows various patterns. We used the annual rice crop calendar of Bangladesh fixed out the rice planting, development and harvested period. Then, selected the rice paddy field from dominant cropping pattern map and google earth very high-resolution images as the area of interest (AOI). According to the rice growing season and rice paddy field, we extracted the spectral signature of various rice pattern. The spectral signature has been collected as; Boro rice and other crops, Boro-Others crop-Amon rice, Aus-others crop, Others crop-Aus-Amon, Others. At least 100 AOI have been selected for each cropping pattern and set a threshold value for each class. More than 700 AOI's for each year selected for spectral signature extraction and then used the supervised classification and maximum likelihood classifier (MLC) used for rice area identification. the beginning the NDVI values considered below 5000 and reached to the peak up to 10000 and then again fall. In case of single rice pattern, the spectral signature shows a folded pattern. In double and triple rice case, it's illustrated double and triple fold respectively. Finally, the rice area is extracted and prepared annual seasonal rice area map of each year and season from 2001-2018.

2.4 AWD Suitability Assessment Model

The water saving and methane emission reduction AWD irrigation system upscaling needs to quantitative assessment of AWD viability. The AWD irrigation is the irrigation scheduling management and it's required controlled irrigation system. We evaluated the factors that affected AWD irrigation from literature review, expert opinion and prior knowledge. The factors are two types; dynamic factor (Precipitation and Temperature), ii) static factor (Slope and soil properties). The FAO land evaluation for rice crop water requirement is modified for the AWD rice irrigation. In this study we analysis AWD suitability with bio-physical parameters as four suitable classes; High Suitable, Moderately Suitable, Low Suitable and Very Low Suitable. We used dynamic parameter, effective precipitation from GSMaP (Islam *et al.,* 2018) and decadal average temperature from Terra Climate data, physical parameter; slope data from AW3D30 and Soil properties; drainage, texture, PH, permeability, and inundation data produced by Bangladesh Agriculture Research Council (BARC) as GIS shape file format with FAO soil standard. The soil with high drainage capacity means high percolation rate and low suitability for AWD, the soil texture with clay to sand refers low to high percolation rate means high to low suitability, the high temperature accelerated the ET value and methane emission, the high p^H values also accelerated the methane emission rate, high soil permeability refer high percolation rate. The land inundation is another important factor for AWD irrigation, the low and high inundation land is low suitable for AWD. The slope is also important factor for AWD, the land with high slope is less suitable for AWD irrigation. The static parameters are reclassified according to the suitability and produced physical soil suitability map for the AWD. AWD irrigation is mainly defined as irrigation management and control the irrigation scheduling. The precipitation is the most important factor for AWD irrigation, the high precipitation rate refers to the less control for irrigation scheduling means less suitable. The dynamic parameter are makes decadal averaged and seasonal composite with rice calendar. The seasonal composite map is classified according to the AWD suitability classes and assign score of each class according to the importance (SYS *et al.* 1993). The static parameter also reclassified and scored as same way. In the table 2 and 3, the parameters and scoring values shown in detail. The reclassified and scored parameters are weighted according to the importance and finally conducted weighted overlay operation for

AWD suitability map.

Table 2: Physical and soil properties and scored based on importance for AWD suitability

Parameter	High Suitable (5)	Moderate high Suitable (4)	Moderate low Suitable (3)	Low Suitable (2)	Not Suitable (1)	Weight
Soil Texture	Silt loam	Fine Sandy loam	Silt Clay	Sandy Loam	Fine Sand/Corase	25
Drainage	Imperfectly drain	Poor drained	Moderately well drain	Well drained	Very Poor drain	20
Soil Moisture	200-300mm	300-400 mm	100-200mm	>400mm	<100 mm	15
Soil Permeability	Slow	Slow-moderate	Moderate	Mixed	Rapid	10
Soil Inundation	Medium low land	Medium highland	Low land	Highland	Very highland	10
Slope	0 – 0.40	0.40-0.60	0.60-0.80	0.80-2.0	>2.0	10
Soil P^H	5.5-7.3	7.3-7.8	7.8-8.4	4.0-5.0	<4.0 and >8.4	10

Table 3: Climatic parameter and scored based on importance with physio-soil factors for AWD suitability

Parameter	High Suitable (5)	Moderate high Suitable (4)	Moderate low Suitable (3)	Low Suitable (2)	Not Suitable (1)	Weight
Effective Precipitation	200-300mm	300-400mm	400-500mm	500-800mm	>800mm	50
Temperature	<27	27-29	29-31	31-33	>33	20
Physio-soil	5	4	3	2	1	30

2.5 Sensitivity Analysis

The factors that affected the AWD irrigation suitability are physical and climatic parameter. The physical parameter (Soil texture, drainage, pH, permeability, slope, inundation, moisture) are considered as dimensionless as mean there is negligible changes with seasonal variation. But the climatic parameter (temperature and precipitation) is dynamic and shows seasonal variation. In this study, we prepared a dataset based on the physical parameters and considered as constant parameter. The climatic parameter; temperature and rainfall are considered as individual parameter. As a result, the three main parameters are sensible to the AWD suitability class of the rice area of Bangladesh. There are three different scenarios with the different assigned value are affected AWD suitable class (Table 4). The sensitivity of the scenarios is evaluated and chose the best fit scenario A for the above suitability analysis over the Bangladesh.

Table 4: Physical and climatic parameter with different weighted value-based scenarios for AWD sensitivity

Case	Effective Precipitation	Temperature	Physical Suitable
A	50	20	30
B	40	20	40
C	50	30	20

3. RESULT AND DISCUSSION

3.1 Rice Area

The rice area of the country gradually increased, and the seasonal rice area also demonstrated a great variation. The rice producing area of the country was 10.8 Mha in 2001, gradually increased up to 11.8 Mha in 2016 and again deceased in 10.68 Mha in 2018. It's seems the rice area of the country reached saturated state and fluctuated around 10 Mha with seasonal variation. The distribution of the rice area also showed variation among the season and region. The market price, weather condition, disaster likes; flood and drought are the factors that determined the rice area of the country. The comparatively less rainfall and high elevated, central north and north-western part of the country is the major rice producing area in the country. The Boro-Amon rice cropping pattern is the dominant cropping pattern in the study area. The central north and north-west region, mainly Mymansing, Rangpur and Rajshahi district are the major Boro-Amon rice area in Bangladesh. The central and south-central part of the country area the Aus rice producing area in the country. In figure 5 illustrated the rice crop distribution and pattern in the study area. The Amon rice area was the dominant rice growing season but gradually decreasing from 5.71 million ha in 2001 to 4.66 million ha in 2018. Although the favorable condition the Amon rice area decreasing due to the comparatively less per unit yield (2.41 tone/ha). The dry season Boro rice area increasing day by day from 3.56 million ha in 2002 to 4.59 million ha in 2018 in the study area. The high cost and fully irrigated Boro rice area increased due to the high per unit yield (3.78 tone/ha) and less disaster risk. Due to the lowest yield and high disaster risk, the rainy season Aus rice area is the lowest rice growing season and fluctuated around 1-1.5 million ha. In figure-6 shows the area of different rice area in Bangladesh. The overall rice cultivated area in the country from 2001-2018 showed in figure 6.

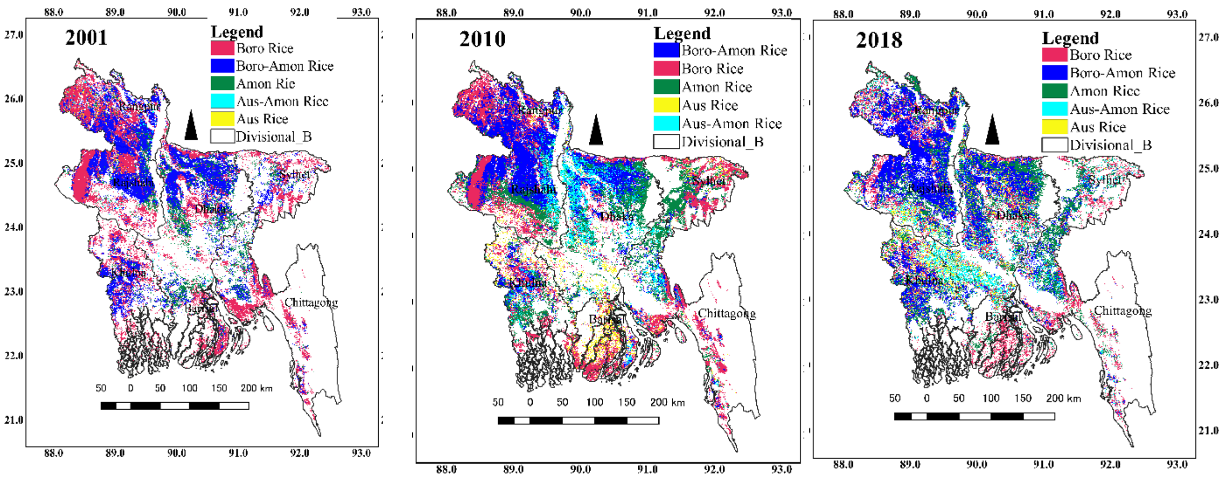

Figure 5: Rice cultivated area and cropping pattern distribution map of sellected year.

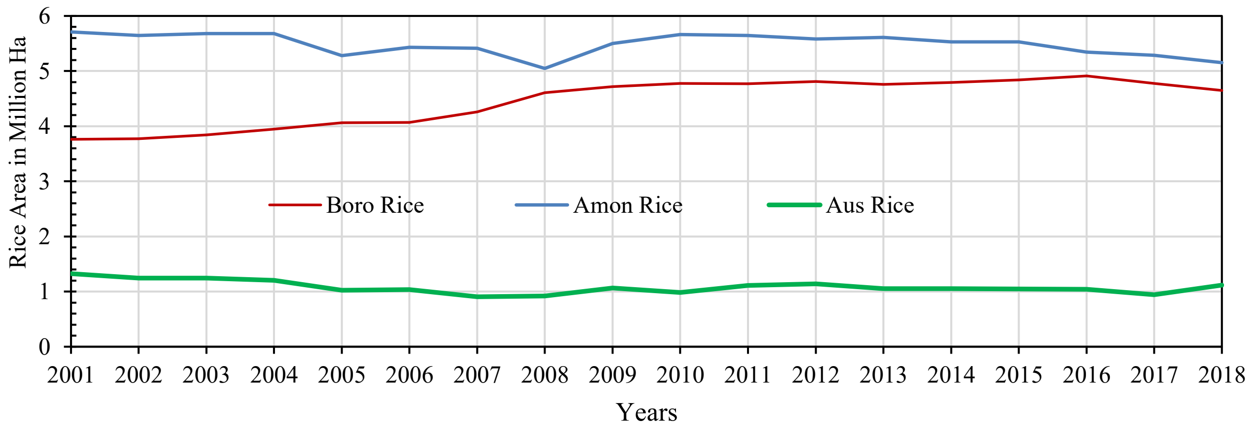

Figure 6: Seasonal rice area statistics of Bangladesh 2001-2018

3.2 AWD Suitability Assessment

AWD suitable area is refers the rice area with high potential for AWD irrigation implementation. There is a great seasonal variation of AWD suitability area in the country. The AWD irrigation mainly depends on the irrigation system. To get the maximum benefit from the AWD irrigation, it's needs to strictly maintain the irrigation scheduling. The high precipitation rate means the uncontrolled irrigation system refers less suitable for AWD irrigation. In Bangladesh, the dry season Boro rice is almost rainless and as a result highly suitable for AWD irrigation. The 80% of total rainfall occurred in the wet season, as a result the Aus and Amon rice is the less suitable for AWD in terms of precipitation. The soil properties show less seasonal variation and considered as static parameters. Currently, Bangladesh implementing AWD irrigation in a very limited area only in Boro rice season. Based on the physical soil properties, the 59.45% area are highly suitable, 38.82%, 1.35% and 0.37% area are moderately, low and very low suitable respectively (Figure 7.a). The seasonal AWD suitability in Boro season, the highly suitable area has been estimated 41.21% and the moderately suitable, low suitable, very low suitable follows as 53.3%, 5.44% and 0.06% of the total Boro rice area. The Aus rice season is the least suitable season with highly suitable, moderate suitable, low suitable and very low suitable area are 0.96%, 10.69%, 32.13% and 56.3% of total Aus rice growing area. The highly suitable Amon rice area has been estimated 7.45% of the total Amon rice growing area and the moderately, low and very low suitable area are respectively 32.7%, 37.73% and 22.12% (Figure 7.b).

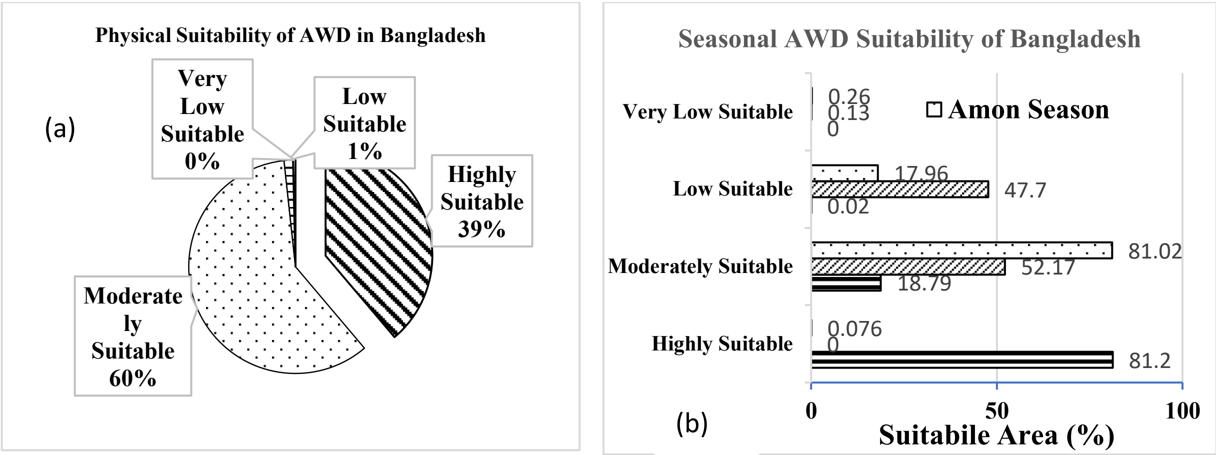

Figure 7 (a). AWD suitable rice area statistics based on the physical properties; (b) AWD suitable rice area statistics based on the physical and climatic parameters of Bangladesh

The central-northern and central-western part of the country area highly suitable area based on the physical and soil properties. The AWD suitable area greatly influenced by climatic parameters. The climatic parameter especially the temperature and precipitation changed the physical suitability. The Boro rice season is the most suitable season followed by Amon and Aus season for AWD irrigation application. The northern and north-western part of the country is the highly suitable for Boro AWD irrigation. The Aus season is the least suitable season for AWD irrigation, and the Amon season is moderately suitable for AWD irrigation in Bangladesh. Figure 8 illustrated the spatial suitability distribution of Boro, Aus and Amon rice season.

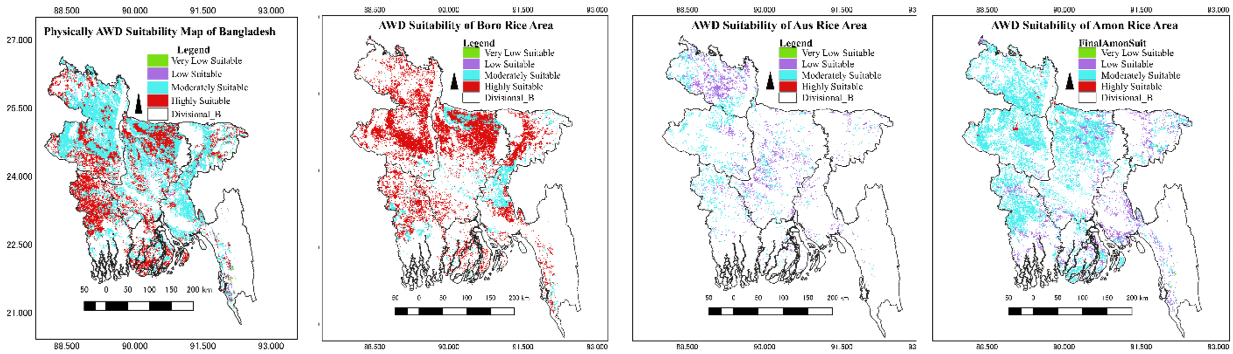

Figure 8. AWD suitable Boro, Aus and Amon rice area based on physical and soil properties and physio-climatic parameters over Bangladesh.

3.3 Sensitivity of AWD Suitability

The AWD suitable area of Bangladesh shows seasonal variation with the climatic parameters. The three different scenarios A, B and C carries different values of effective precipitation (Ep), temperature (T) and physical soil (Ps) parameters. In case A- Ep (50), T (20) and Ps (40); B- Ep (40), T (20) and Ps (40); C- Ep (50), T (30) and Ps (20) are assigned to investigate the sensitivity of AWD rice area. The Boro rice area is lower estimated in case of B (69.06%) compare to the A (79.31%) and C (87.37%) highly suitable area but the moderately suitable area shows the opposite scenario (table 5). In Aus rice season the B case is illustrations higher estimation compare to A and C, which is just the reverse response in terms of Boro rice season. The Amon rice season also demonstrated the same pattern as Aus rice season. The effective precipitation is the most sensitive to the AWD suitability and the physical soil parameter moderately, and temperature are less sensitive to the AWD suitability in Bangladesh. With increases the precipitation the suitability decreased as a result the Boro rice season is the most suitable for AWD irrigation, the Amon and Aus rice season are followed Boro rice season according to the suitability. The Aus rice season is the highly precipitation season and less suitable for AWD irrigation. Based on the physio-climatic characteristics of Bangladesh, we used scenario A as the best fit and standard suitability scenario for this study.

Table 5: Sensitivity of the AWD suitability in terms of physio-climatic parameter

Rice Season	Boro Rice Area (%)			Aus Rice Area (%)			Amon Rice Area (%)		
Suitability/Cases	**A**	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**C**
Highly Suitable	79.312	69.069	87.375	0.327	8.471	0.218	0.997	0.966	0.023
Moderately Suitable	20.625	30.723	12.443	15.571	23.680	8.300	50.444	62.040	38.882
Low Suitable	0.061	0.206	0.181	71.465	55.457	64.407	47.364	35.407	56.420
Very Low Suitable	0	0	0	12.635	12.389	27.073	1.193	1.585	4.674

3.4 Compare the AWD Suitability Class with Field Data

This study determinate AWD suitable area have been compared with the field data. The AWD irrigated rice data on water use, crop height, and yield have been collected from Rural Development Academy (RDA). All together 86 field all over the country have been applied AWD irrigation under RDA supervision. In Bangladesh, the AWD irrigation applied only in the Boro rice season and this data are collected in 2018, Boro rice cultivation season. The data are collected from the AWD and non-AWD irrigated rice field. The water used in AWD field and non-AWD irrigated filed compared and calculated the water saving from the AWD irrigation application. Among the 86 field, the 20 filed save more than 30% water, 58 field save 30-20% water and 8 field save less than 20% water compared with non-AWD irrigated rice filed. Amon the >30% water saving field (20), 19 field area within the highly suitable AWD irrigated area and 1 field in moderately suitable area. The 20-30% water saving field (58) are also follow the suitability pattern, only 5 field are in moderately suitable area and rest of them are in highly suitable area. There are 8 less water saving (<20%) filed, 6 field are in moderately suitable area and 2 field in highly suitable area. In figure 9 illustrated the AWD water saving field with the AWD suitable classes all over the country. The highly suitable and water saving field are mostly located in the north-wester part of the country. The less water saving filed are mostly located in moderately suitable area and south-eastern part of the country. Although, the AWD irrigation water saving depends on the intellectual irrigation management, but our methodology applied suitable classes and the field data shows a very good agreement.

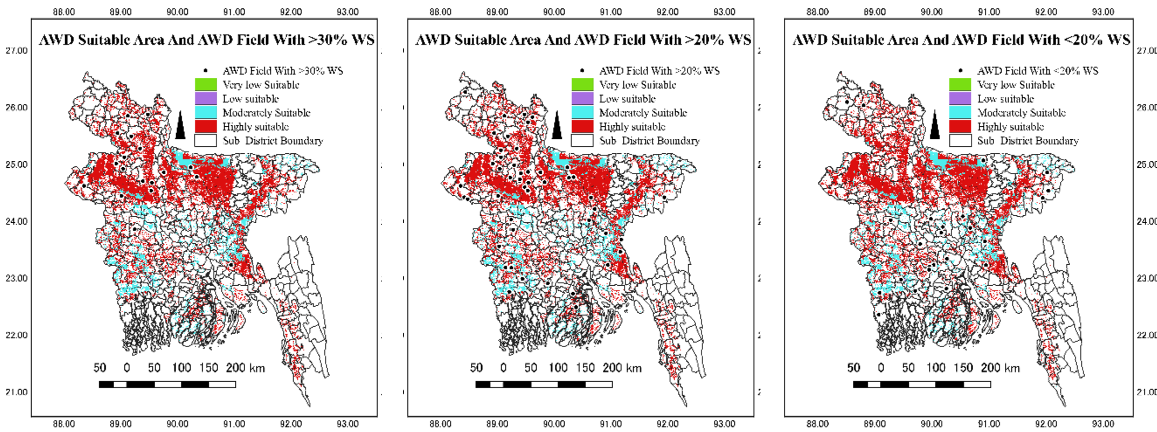

Figure 9: Comparison of the AWD suitable area and water saving filed data

4. CONCLUSIONS AND FUTURE WORKS

This study demonstrated the geospatial data-based rice area (2001-2018), AWD suitability classification and comparison the suitability classes with the field data. Precipitation is the most sensitive to AWD suitability, with increases the precipitation the suitability decreased. The Boro rice season is the most suitable and Aus rice season is the lest AWD suitable season. The model demonstrated AWD suitable rice area and the AWD irrigated rice field data exposed a very high-level agreement. The higher water saving AWD irrigated rice field are in the model demonstrated highly suitable AWD irrigated rice area. The adoption of the AWD irrigation systems in the farmers level, the proper information on AWD suitable time and places. The potential suitable area for AWD irrigation in Boro, Aus and Amon rice season will help to disseminate the AWD irrigation system in Bangladesh. In future, we are interested to assess the socio-economic suitability of AWD irrigation system in Bangladesh.

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