Assessment of Cropping Patterns for Sustainable Intensification in Drought Prone Ecosystem using Remote Sensing and Geospatial Modeling

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Background of the Project:

Bangladesh Government has given high priority to sustaining groundwater use for irrigation. Hence, it is important to conduct agricultural land use and cropping patterns analysis and their implication to foster sustainable intensification (SI) strategies in the drought-prone regions of Bangladesh. Remote sensing and geospatial modeling can play a vital role to assess cropping patterns and availability of natural resources on the ground and allocate them to the judiciary for SI in agriculture. Geospatial modeling can help allocate an appropriate cropping pattern based on the best judicial use of available natural resources. Hence, in order to facilitate sustainable cropping intensification in the agro- environment of Bangladesh, the current research project has been initiated to carry out in the drought-prone agro-ecosystems prevailing in the Barind Tract region of Bangladesh.

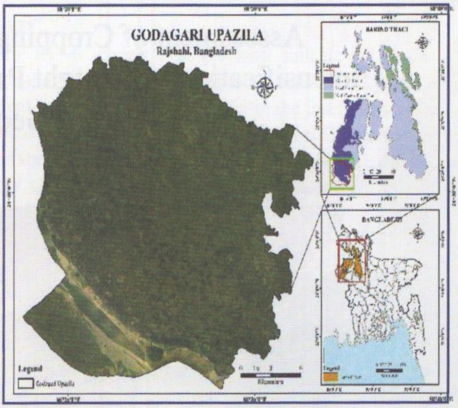

Fig 1: Study Area

Project objective(s):

- To develop dry season's crop type maps in the study areas using remote sensing image analysis.
- To develop agro- environmental resources and constraints geo -database from remote sensing image analysis and secondary data acquisition.
- To suggest location-specific suitable cropping patterns for sustainable intensification by geospatial modeling.

Statement of the Problems:

Remote sensing and geospatial modelling can play a vital role in assessing cropping patterns and availability of naturalresources and allocate them judiciary for SI in agriculture. However, classification of smallholding farms has been challenging, particularly due to their smaller plot sizes and huge variability over time and space with diversified crops. At the same time, farmer's characteristics in case of cultivation time and period were much varied, which leads to more complex cropping systems. To achieve precision, and sustainable intensification in agriculture, GIS and Remote sensing with machine learning grab attention and provide solutions to tackle those complex systems.

Crops	Dominant varieties
Rice	BRRI- 28 & 63
Wheat	BARI Gom 25, 26 & 28
Maize	981, Super 45, Pinal 92
Lentil	BARI Moshur 4, 6 & 8
Mustard	Torry 7/BARI Sharisha 14
Potato	Diamant & Asterix

Tab 1: Crop inventory

Materials: A crop inventory and total 13 types of RS-GIS data collected from different sources. See tab. 1 and 2.

Data	Description	Source
GTPs	Yearly (rabi Season)	Primary
Sentinel 2A	MSI, 10m, 13 bands	GEE
Temperature	NOAH land Surface Model, 0.1°/11.1km	Earth Data
Rainfall	GPM, 0.1°/11.1km	GPM
DEM	SRTM 30m	USGS
Slope	SRTM 30m	USGS
Aspect	SRTM 30m	USGS
Soil Type		BARC
Soil Texture	HYSOGs250m	Earth Data
Soil Reaction		BARC
Soil Consistency		BARC
Soil Moisture	NOAH land Surface Model, 0.1°/11.1km	Earth Data
Land Type		BARC
LULC	Near real-time global 10m LULC mapping	DW

Tab 2: Data sources and characteristic

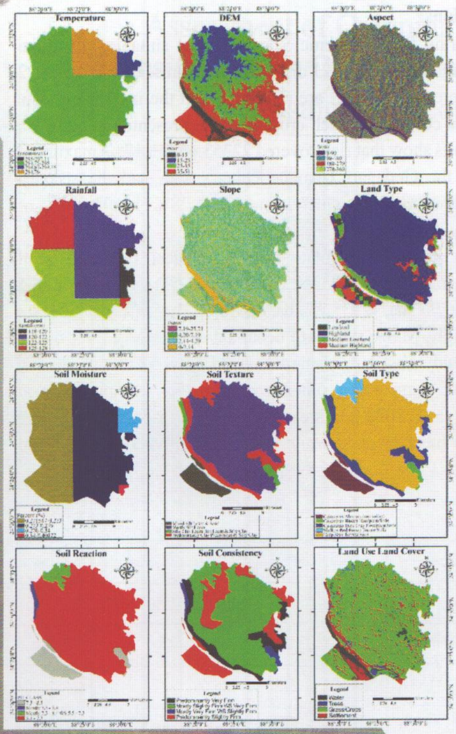

Fig 2: Used data

Methodology: The study has adopted a robust methodology with incorporating MLAs and AHP-GIS based approach.

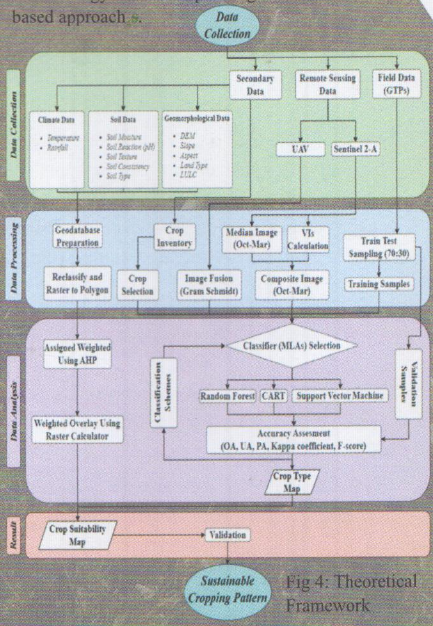

Fig 4: Theoretical Framework

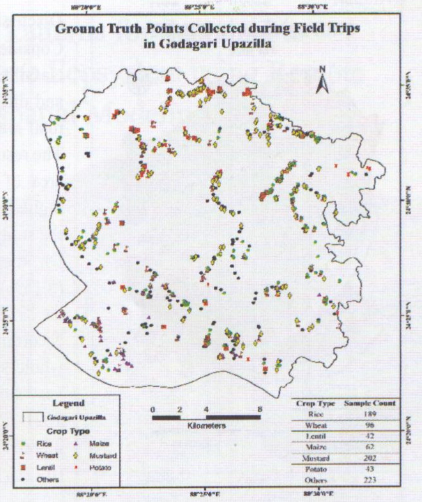

Fig 3: GTPs during 2022-23 dry season

Results:

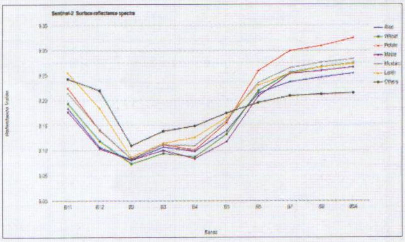

Fig 5: Band-wise reflectance value

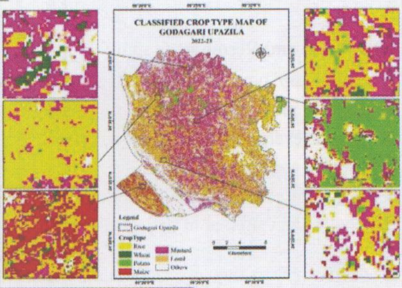

Fig 6: Crop type map for 2022-23 dry season

P/S	2020-21	2021-22	2022-23
OA	0.86	0.92	0.88
Kappa Statistic	0.81	0.91	0.86
F1 Score	0.82	0.93	0.87

Tab 3: Accuracy assessment

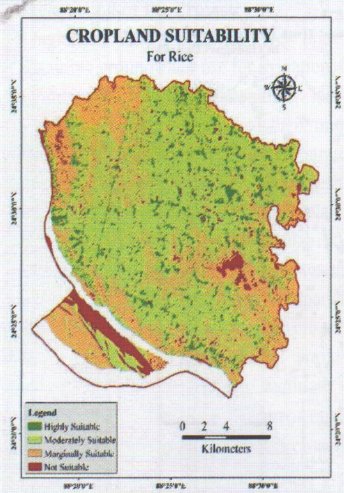

Fig 7: suitability analysis for rice

Discussions:

Considering RF in scheme 5 as the most suitable MLA, the classified map for 2020-21 dry season is represented in figure 22 and different crop types are represented in the inset maps. The total area covered by each crop type is represented in table 10. The results show that rice covered 22253.46 (45.17%) maximum area of the Godagari Upazila. Other's area had the second-highest area coverage which is more than 28% (14107.45 ha) of the study area.

On the other hand, potato (9.31%), wheat (6.75%), lentil (5.15%), maize (4.66%), and mustard (0.32%) covered 4588.75 ha, 3326.96 ha, 2535.75 ha, 2296.02 ha, and 159.63 ha accordingly. Maize and lentil occupied equally about 5% of the whole study area but mustard covered only 0.32% which was very small compared to other crop types. For Cropping Season 2021-22 and 2022-23, area occupied for rice (36.72% and 28.86%) have dropped while mustered cultivation was busted (0.32% to 12.38% and 26.89%) according to analysis.

Class/Area	Rice		Wheat		Maize		Mustard		Potato		Lentil	
	Hectare	%	Hectare	%	Hectare	%	Hectare	%	Hectare	%	Hectare	%
S1	3024.1	6.2	5234.7	10.7	3246.3	6.6	1957.9	4.0	4381.8	8.9	3202.3	6.5
S2	25930.2	53.0	30252.8	61.7	27756.8	56.6	16834.7	34.3	14252.6	29.1	29604.2	60.4
S3	13756.4	28.1	7340.6	15.0	11755.5	24.0	22114.0	45.1	23863.4	48.7	9987.5	20.4
N	6220.9	12.7	6193.2	12.6	6262.7	12.8	8114.7	16.6	6523.5	13.3	6227.2	12.7
S1+S2	28954.2	59.2	35487.5	72.4	31003.0	63.2	18792.6	38.3	18634.4	38.0	32806.5	66.9
S1+S2+S3	42710.6	87.3	42828.0	87.4	42758.6	87.2	40906.5	83.4	42497.8	86.7	42794.1	87.3

Tab 3: Area against suitability classes

Conclusion and Recommendation:

Accurate crop type mapping and crop suitability assessment is a crucial prerequisite for monitoring agricultural productivity. However, this remote sensing-based crop type is quite difficult for Bangladesh conditions, even during the rabi/dry season, particularly due to small plot sizes and high heterogeneity in their spatial and temporal distribution. The study clearly brought out the spatial distribution of selected crops derived from geospatial modeling conjunction with machine learning and evaluation of climatic, soil and morphological variables in GIS context.

- ✓ Policymakers may use the findings to develop a crop production plan and provide special agricultural incentive programs to boost our nation's food supply.
- ✓ Findings may be utilized in others project associated with BARI, BRRI, BINA and other organizations.
- ✓ Similar studies may be carried out in other regions to develop location/case specific methodologies.
- ✓ Microwave and lidar sensors may enhance the capabilities to carry out the study in all year round.

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