# FINAL REPORT
# EARTH OBSERVATION FOR MONITORING AND EVALUATION OF BLUE GOLD INTERVENTIONS

# Glossary

| | |
|---|---|
| BGP | Blue Gold Program |
| EO | Earth Observation |
| FR | Final Report |
| LULC | Land Use and Land Cover |
| M&E | Monitoring and Evaluation |
| MTR | Mid-Term Report |
| NDVI | Normalised Difference Vegetation Index |
| NIR | Near Infrared |
| QAQC | Quality Assurance and Quality Control |
| SAR | Synthetic Aperture Radar |

# Contents

## Executive Summary

This is the Final Report for the Earth Observation mapping for Monitoring and Evaluation of Blue Gold interventions in Bangladesh project. The project is executed by Satelligence, with the assistance of a local consultant, for the benefit of the BGP 'Monitoring Reflection and Learning Team'.

The Final Report discusses the large-scale effects of BGP interventions on agricultural patterns and trends in four districts of the polder region in southern Bangladesh. A satellite-based approach (combining Landsat and Sentinel-I) shows that cropping intensity has increased on average for most BGP polders with 50% to improved farmer practices and regional interventions. The increase in cropping intensity is observed for both 2017 and 2018 compared to the baseline (average of 2011-2015).

# 1. Project Scope

## 1.1 Blue Gold Program

The Blue Gold Program (BGP) is a joint initiative funded by the governments of Bangladesh and the Netherlands. The development project began in March 2013 and is scheduled to last six years. The objective of the BGP is to reduce poverty for 200,000 households living on 115,000 ha of selected coastal polders, in the districts of Patuakhali, Khulna, Satkhira, and Barguna, by creating a healthy living environment and a sustainable socio-economic development.

## 1.2 Project rationale

In order to monitor the outcome of BGP interventions the program is in need of delta wide Monitoring & Evaluation (M&E) solutions. Remote sensing applications have proven to be very good M&E tools for larger areas because they deliver accurate results and are cost-efficient. However, remote sensing techniques have not yet been applied on a large scale in Bangladesh. The project also seeks to engage with governmental institutions to raise awareness of the capabilities (and limitations) of using innovative technologies such as remote sensing for agriculture and water.

Funds for additional monitoring until the end of the program (2020-2021) may become available in case the project reaches its goals and the outcomes have proven to be beneficial for BGP.

## 1.3 Concept & Objectives

The concept of this project is to evaluate the success of BGP interventions by making use of Earth Observation (EO) methods. For BGP, the agricultural (change in) productivity will be monitored, with *cropping intensity* and *changes in cultivated area* as main indicators.

The concept objectives of this technical project are 1) to create a baseline for agricultural productivity, 2) show changes in agricultural productivity - which could be related to BGP interventions, and 3) make agricultural productivity information accessible and understandable for the BGP technical team to use for further (intervention) planning.

Performance of the polders are estimated for the start of BGP (2011-2015) and two years during the project (2017, 2018). The BGP started out in March 2013 but most interventions did not have significant effect until 2017. Due to the introduction of higher resolution Sentinel-I data in 2014, especially helpful during the rainy season and for aquaculture mapping, the baseline was set for the years 2011-2015.

The outcomes of this project can be used by the Monitoring and Reflection Team of BGP to assess the success of polder interventions and engage with governmental institutions.

### 1.4 Area of Interest

The pilot project has been carried out in the districts of Patuakhali, Khulna, Satkhira, and Barguna. BGP and neighbouring polders are included (Figure 1). BGP polders have an estimated area of 115,000ha; including all the non-BGP polders this results in an area of around 500,000ha.

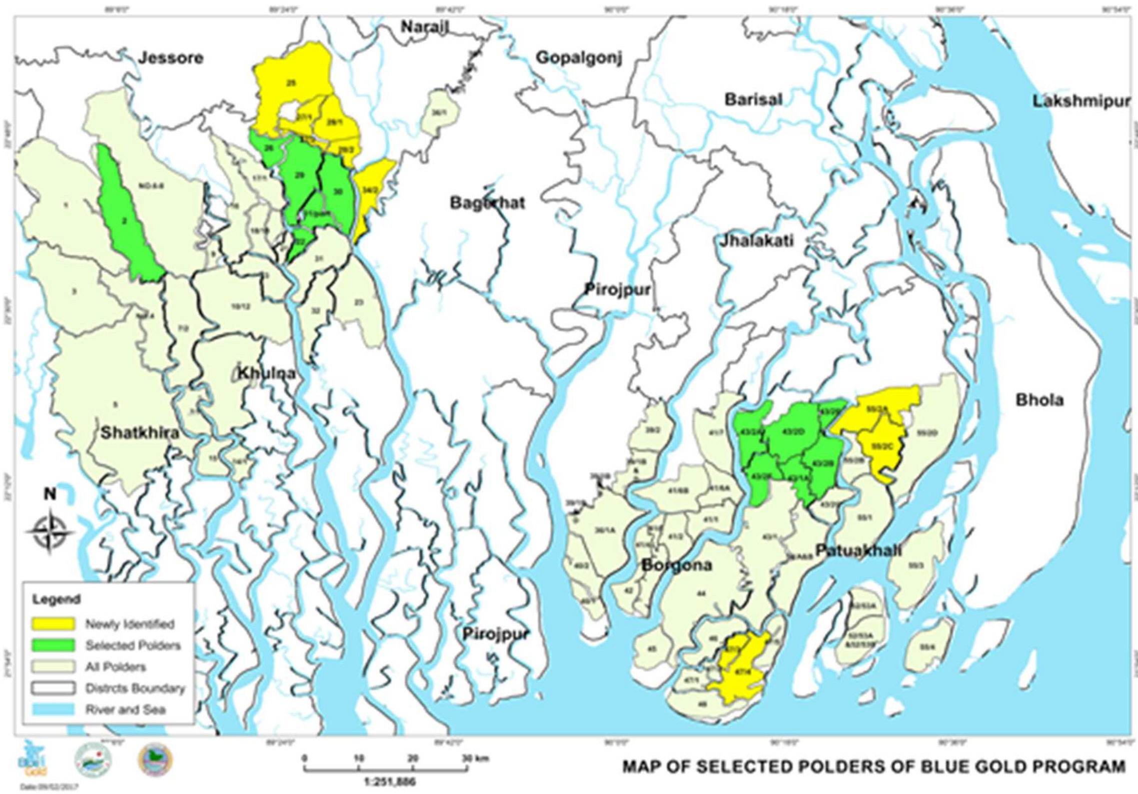


*Figure 1. The project area consists of BGP- and surrounding polders in the districts of Patuakhali, Khulna, Satkhira, and Barguna.*

## 1.5 Results

***Cultivated area and cropping intensity***

Delivered are the number of crop cycles per year and the extent of cultivated area per growth season (rabi, kharif-I, kharif-II). Results are delivered as pixel maps and summarized statistics per polder. Maps are delivered per season for the baseline (2011-2015) and impact monitoring years 2017 and 2018. Statistics are based on comparing the years 2017 and 2018 with the average of the baseline (2011-2015), per polder.

| | |
|---|---|
| Coverage | Polders in Patuakhali, Khulna, Satkhira, and Barguna (see 'work area') |
| Date(s) | Baseline: 2011-2015<br>Impact monitoring: 2017, 2018 |
| Thematic information | Cultivated area (rice, other agriculture, aquaculture, other classes)<br>Cropping intensity |
| Timeliness | Map per growth season (rabi, kharif-I, kharif-II) |
| Geometric resolution | Baseline: 30m pixel size, and 30m pixel size or better for 2015<br>Impact monitoring: 30m pixel size or better |
| Accuracy | 90% or better |
| Data format | GIS-ready data in standard raster data formats: GeoTiff, shapefile, kml, and high quality .pdf, .jpeg for reporting. Statistics per polder will be delivered as Excel file. An animation showing the changes over time is also created. |
| Map projection | UTM, WSG84 or as requested |

Data provided by BGP to Satelligence:
- Blue Gold Polders: Polygons of Blue Gold polders
- Other Polders BWDB: Polygons other polders in Patuakhali, Khulna, Satkhira and Barguna

For the statistical analysis the 'Other Polders BWDB' and 'Blue Gold Polders' shapefiles were used to determine the locations and size of the polders. One polygon is listed as 'unknown' and contains the city of Khulna (no polder name was provided in the shapefile). Some of the non-BGP polders are partly inside- and partly outside the Area of Interest. The results for these polders are solely based on the part of the polder that lies within the Area of Interest.

# 2. Methodology of analysis

## 2.1 Approach

In short Satelligence undertook the following approach:
1. EO map products are delivered for the baseline assessment (2011-2015) and impact monitoring years 2017 and 2018. The timing of Bangladesh crop cycles were studied to determine the exact observing dates. Several satellite sensors (Sentinel-1 in combination with Landsat) were used to get the best results.
2. The EO map products were analyzed and statistics of parameters per BGP polder were obtained.
3. The statistical significance of the obtained parameters between BGP polders, and between BGP polders and non-BGP polders, were determined. The statistical significance of differences between years was also investigated.
4. Results are delivered, reported and presented.

A semi-automated satellite image processing system has been developed based on published science. Satellite image calibration, radiometric, geometric and topographic terrain corrections are performed. Calibration is done with the help of field data provided by the local consultant. One critical feature is the application of automated cloud and haze removal and compositing techniques to ensure a minimal amount of cloud cover, and the use of satellite radar that 'sees' through clouds, haze and smoke. The core data stream consists of free satellite data: Sentinel-1A/B radar (every 12 or 24 days) at 10-30m resolution, and Landsat-5,7,8 (every 16 days for each satellite) at 30m resolution. These processed satellite images will be analyzed by applying advanced image classification techniques. A simplified processing chain, including classification, is presented in Figure 2.

The statistics are shown in a table and changes are tested for statistical significance.

## 2.2 Land Use and Land cover (LULC) classification

Input data: Yearly cloud-free Landsat composites and seasonal Sentinel-1 composites

Time period:

| | |
|---|---|
| Sentinel-1 | Baseline 2014 - December 2015 |
| | December 2016 - December 2018 |
| Landsat | Baseline 2011 - 2015 |
| | December 2016 - December 2018 |

The land use classes used in the analysis are:

- water
- urban
- forest (includes: mangrove, shadow trees, forest)
- bare (includes: bare area, sediment, sand, beach)
- fallow*
- cultivated area - dry (other agriculture)
- rice
- aquaculture: inland closed water (culture) fishery**

*fallow is a new class for this FR

**open water bodies cannot be accurately identified as aquaculture from space

Delivered are 1) a seasonal baseline map (2011 - 2015) and 2) a seasonal map for monitoring years 2017 and 2018, based on Landsat-7,8 and Sentinel-1 imagery (aggregated in one product). The following seasons are used:

- Rabi (boro): December - April
- Kharif-I (aus): May - July
- Kharif-II (aman): August - November

### *2.2.1 Classification method*

The classification method (Figure 2) is a supervised classification method, using the gathered field data. Random Forest is the algorithm used. Random Forest is an ensemble method, which uses many small ‘weak’ models to come to a single, robust model. The model is trained on the gathered field data + extra ground truth data from high-resolution satellite imagery for easily distinguishable classes like forest, water and urban areas.

Cloud-free Landsat composites were used for making a ‘base’ classification, distinguishing agriculture from all other classes. In order to make a distinction per season between rice, aquaculture and cultivated area - dry, Sentinel-1 composites were used. Percentages of land use per polder are automatically extracted using a python script.

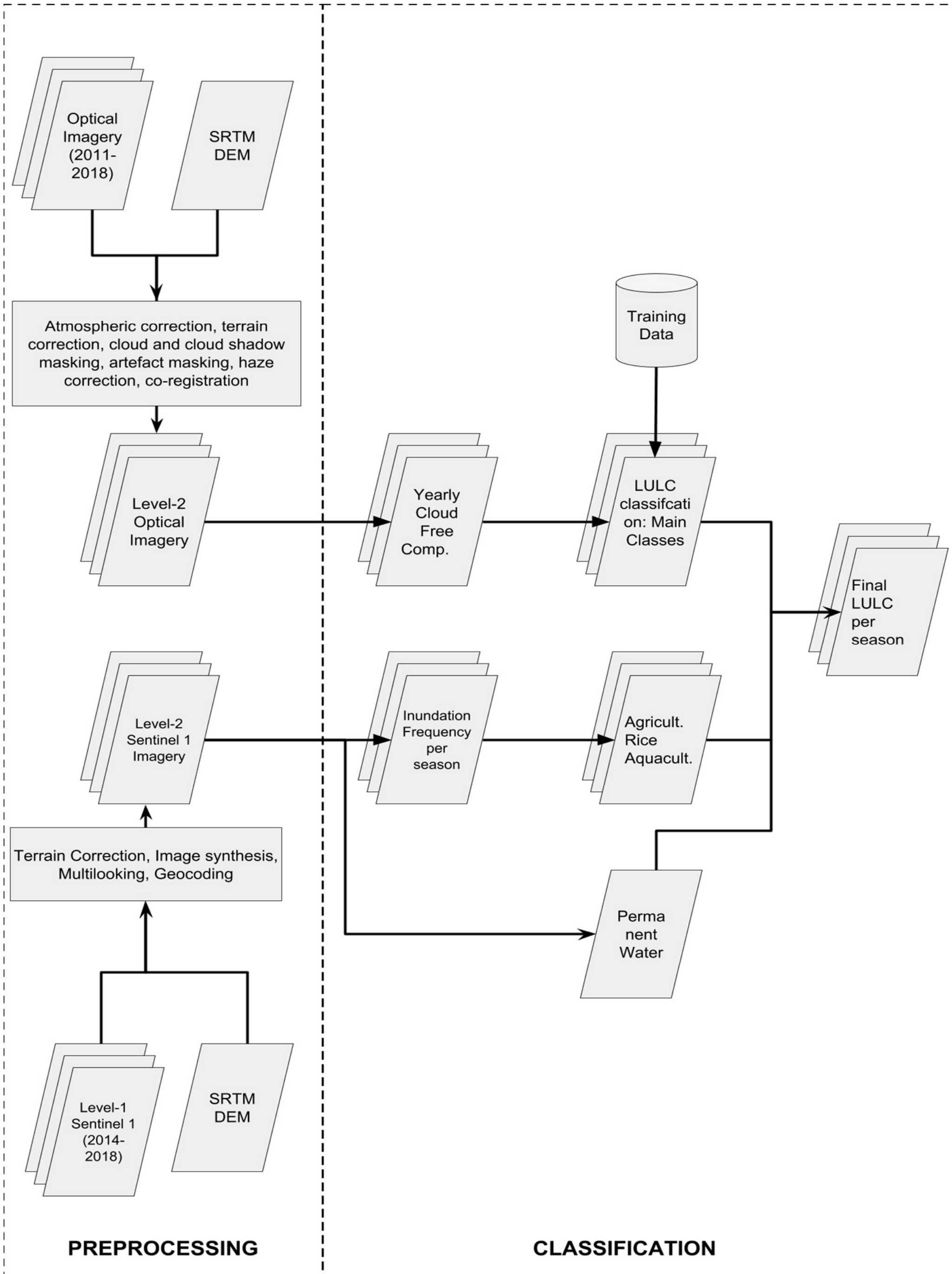


*Figure 2. Overall preprocessing and Land Use classification steps (Satelligence, 2018)*

## 2.3 Cropping (Cultivation) intensity: number of harvests

When vegetation grows, their reflection in the near-infrared wavelengths of the electromagnetic spectrum increases. The most common index used in remote sensing for vegetation is called the Normalised Difference Vegetation Index (NDVI). This index is a ratio between the reflection in the red part of the electromagnetic spectrum and the near-infrared part of the ems. The equation is as follows:

$$NDVI = \frac{(NIR - R)}{(NIR + R)}$$

Where NIR is the reflection in near infrared and R the reflection in red.

Values of NDVI are between -1 and 1. Areas that have very low NDVI are water, urban areas and bare soil. Areas with high NDVI are e.g. mature crops and forest. The large drop and rise in NDVI that is associated with agricultural practices can be used to detect the number of harvests per year.

Input data: Weekly Landsat composites (Landsat-5, Landsat-7 and Landsat-8)

The procedure is as follows:
For each polder, we subset the area which is used for agricultural practices, but we leave out the pixels that are aquaculture throughout the year. The reason we leave out aquaculture from the intensity calculations is that we cannot detect any harvests for aquaculture (water depth cannot be measured and harvesting not observed) and, otherwise the average number of harvests per polder would be underestimated.

### *2.3.1 Significance testing of cultivation intensity changes*

To compare differences in intensity per polder, standard t-tests are not very informative, because the polders contain in most cases many thousands of pixels, which will make p-values approach zero. Instead, we opted to calculate the Cohen's d (Figure 3), which shows the *effect size* between the mean intensities of the baseline, 2017 and 2018. Absolute values of Cohen's d range between 0 and infinity, with effect sizes of 0-0.2 meaning trivial effect, 0.2-0.5 small effect, 0.5-0.8 medium effect and >0.8 large effect.

To summarize, we calculate the mean intensity per year based on the NDVI, which is a number between 1 and 3. Subsequently, we calculate the Cohen's d distribution based on the effect size between the mean intensities.

For comparison of differences in agricultural extent between the baseline and 2017, a standard two-tailed t-test was used.

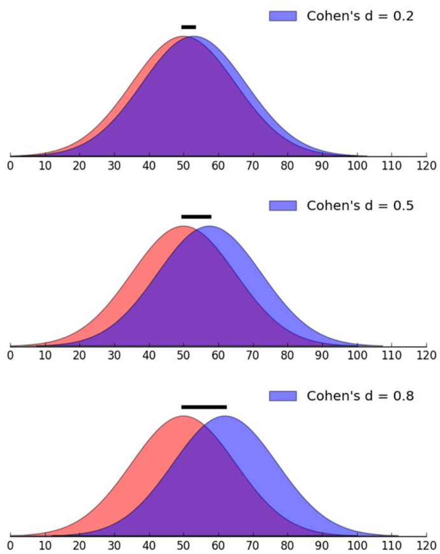


*Figure 3. Cohen's D distribution of a large sample size (Scientifically Sound, 2018)*

### 2.4 Minimum size of observed features

To see a feature reliably with the satellite sensors used, it needs to have a minimum size of 30x30m. Smaller objects often 'share' a pixel with a signature of another object (e.g. a 10x10m pixel can contain both part of a road and part of a rice field), which makes it hard to distinguish features from each other. Therefore, the minimum size of a recorded pixel does not correlate 1:1 with the minimum mapping unit.

### 2.5 Quality Assurance and Quality Control

Accuracy has been determined by crosschecking field data points with project outputs. Since the number of field data points is relatively low to give a good indication of the accuracy we mainly assessed the quality of the products by conducting manual checks. In the Figures below you can see some of the results, also comparing to the methodology used during the Mid-Term Report (MTR) assessment.

As can be seen on the images below (Figures 4 & 5) the resolution has increased from 30 to 10 metres, and the classification of agricultural vs non-agricultural classes is more accurate. On the MTR images we see lower resolution blocks that often cover forest or urban areas, while in the FR images that is not the case.

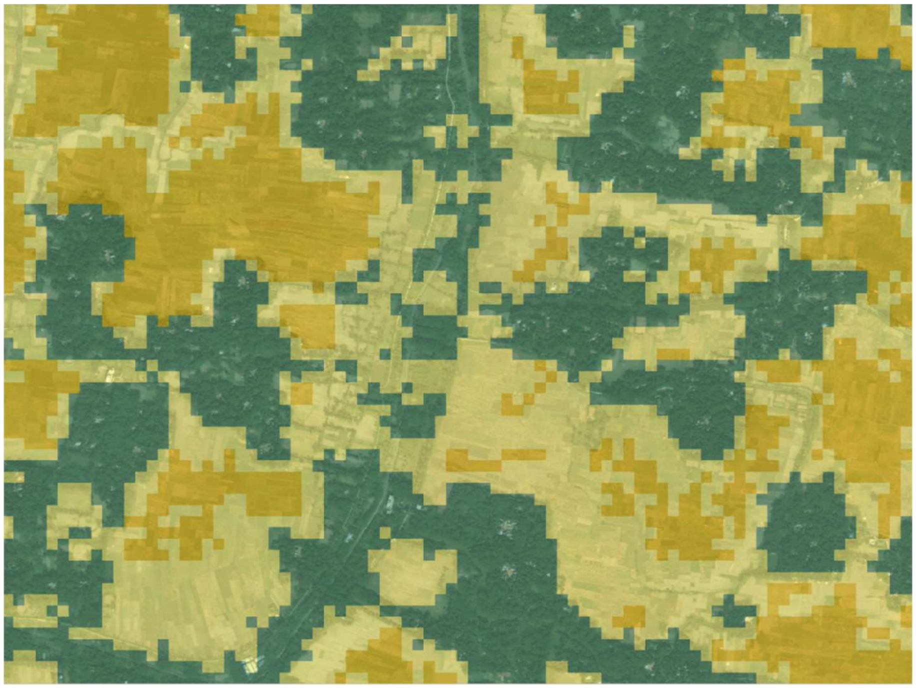

*Figure 4a. Land use classification of other agriculture (Light yellow) and rice (Dark yellow) using the MTR methodology*

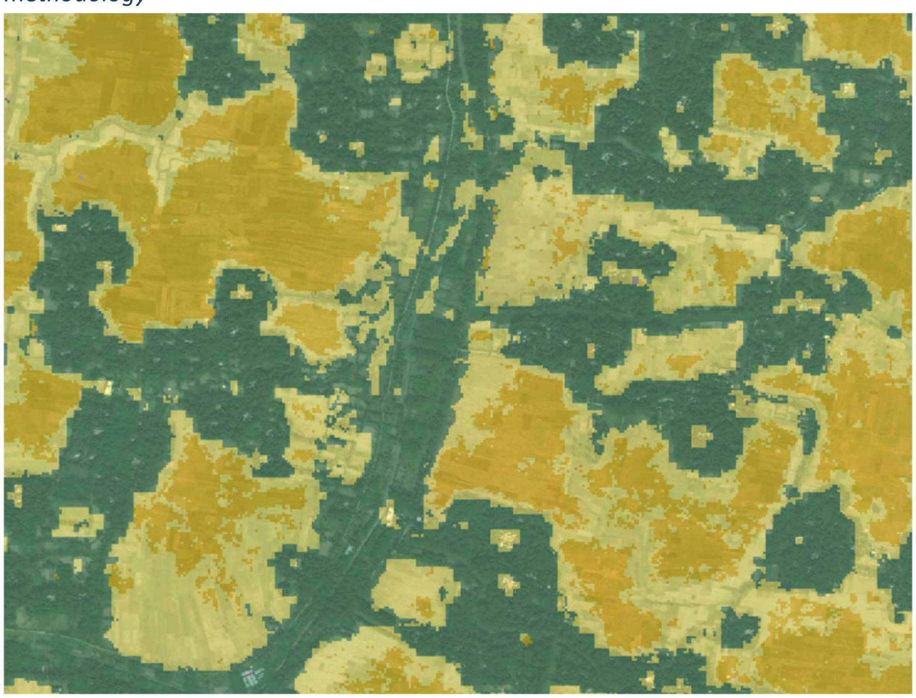

*Figure 4b. Land use classification of other agriculture (Light yellow) and rice (Dark yellow) using the FR methodology*

*Figure 4c. VHR Bing satellite image of the classified areas of Figures 4a&b*

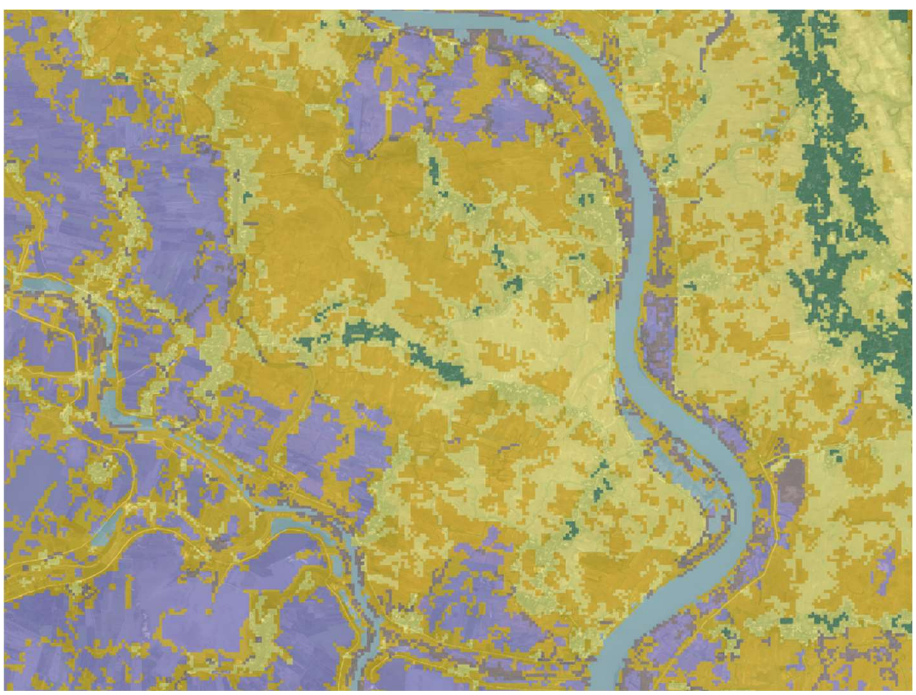

*Figure 5a. Land use classification of aquaculture (purple), other agriculture (Light yellow) and rice (Dark yellow) using the MTR methodology*

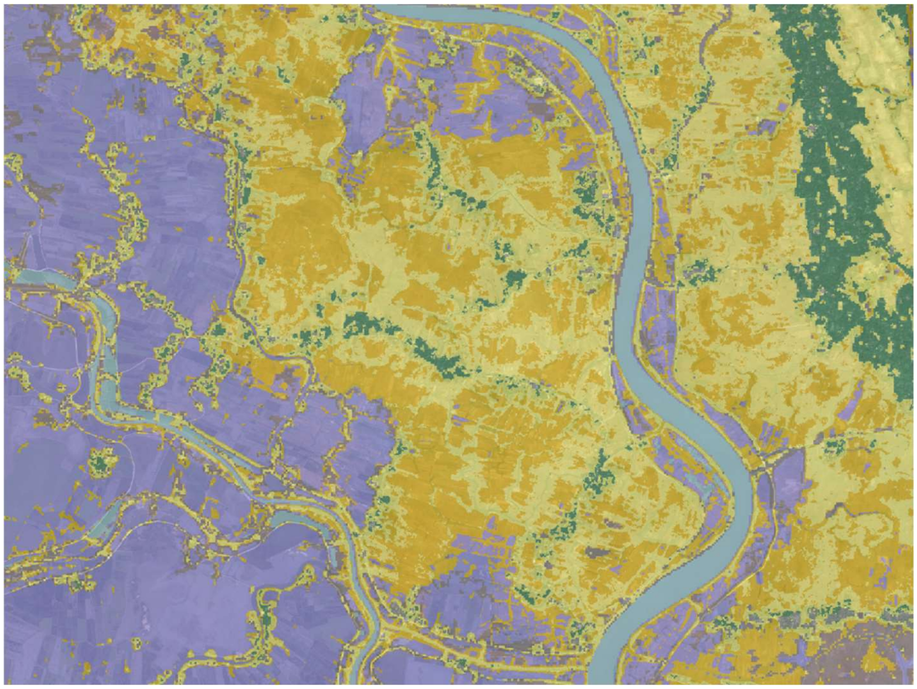

*Figure 5b. Land use classification of aquaculture (purple), other agriculture (Light yellow) and rice (Dark yellow) using the FR methodology*

*Figure 5c. VHR Bing satellite image of the classified areas of Figures 5a&b*

## 3. Co-creation of results

BGP and Satelligence organized several feedback sessions in Dhaka which were fundamental for the development of the results, and for getting an understanding of local context. Furthermore, there were also monthly update calls between the BGP Monitoring Reflection and Learning Team members and Satelligence.

The main moments of contact are given below:

- Proof-of-concept meeting Dhaka, April 2018. During this meeting Satelligence presented the background and methodology of this project to BGP team members. There was a fruitful discussion on the possibilities and limitations of remote sensing applications.

- MTR voice call session, September 2018. During this voice call session the MTR results and feedback from BGP team members was discussed. Feedback was implemented in the final MTR.

- BGP remote sensing & GIS workshop. In collaboration with the Bangladesh Water Development Board (BWDB) and the Department of Agricultural Extension (DAE), BGP and Satelligence organized a remote sensing & GIS workshop of 3 days for government officers, in February 2019. The workshop was very well received. Satelligence developed a training manual for the participants.

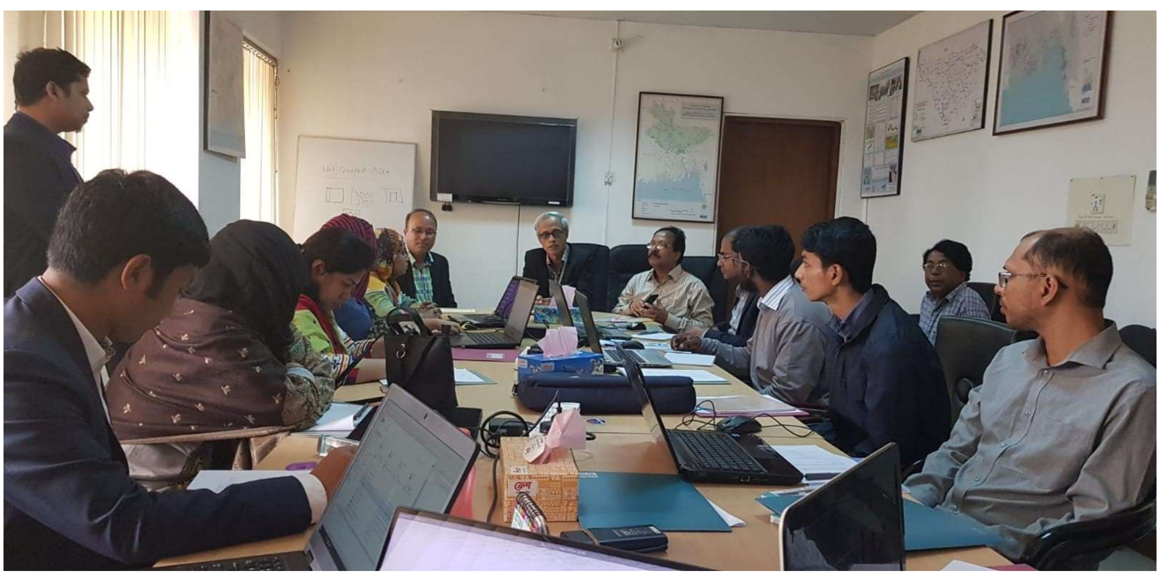

*Figure 6. Remote Sensing & GIS workshop at the BWDB office in Dhaka*

# 4. Results

## 4.1 Land use and land cover

Land use maps were developed for the baseline (2011 - 2015) and 2017 & 2018 (Figures 7-9). These figures show the overall patterns per year, whereas in Appendix B more detailed maps per season, per BGP polder can be found.

From year-to-year there are a few dominant trends visible. Between the baseline and 2017 & 2018 a clear increase in rice cultivation. The overall pattern shows that the extent of aquaculture is lowest during the Rabi season. During the Rabi season we also see the lowest % of rice cultivation, especially visible in Barguna and Patuakhali. During the Kharif-I and Kharif-II seasons, the number of agricultural land used for aquaculture and rice is higher than during the Rabi season.

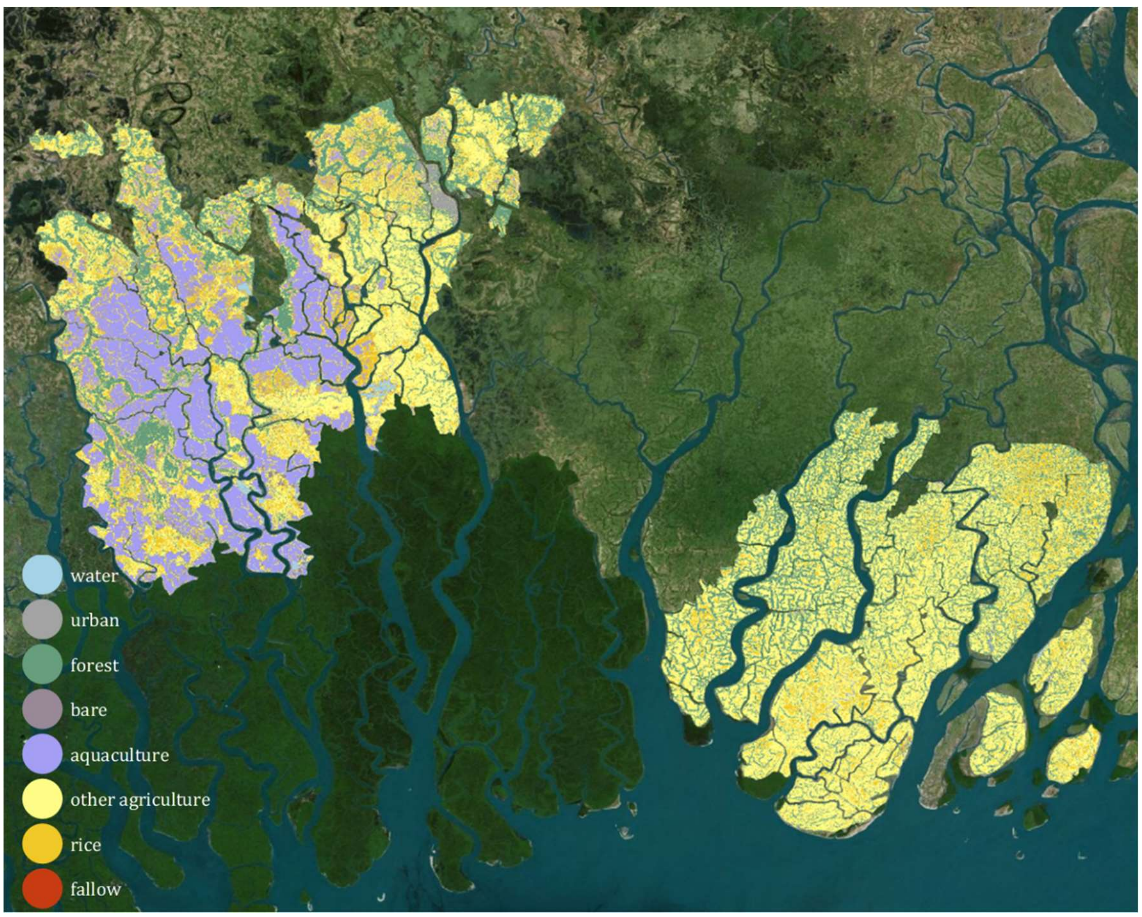


*Figure 7. Overall Land Use classification for the 2011-2015 baseline, created with aggregated Landsat and Sentinel-I imagery (Satelligence, 2019)*

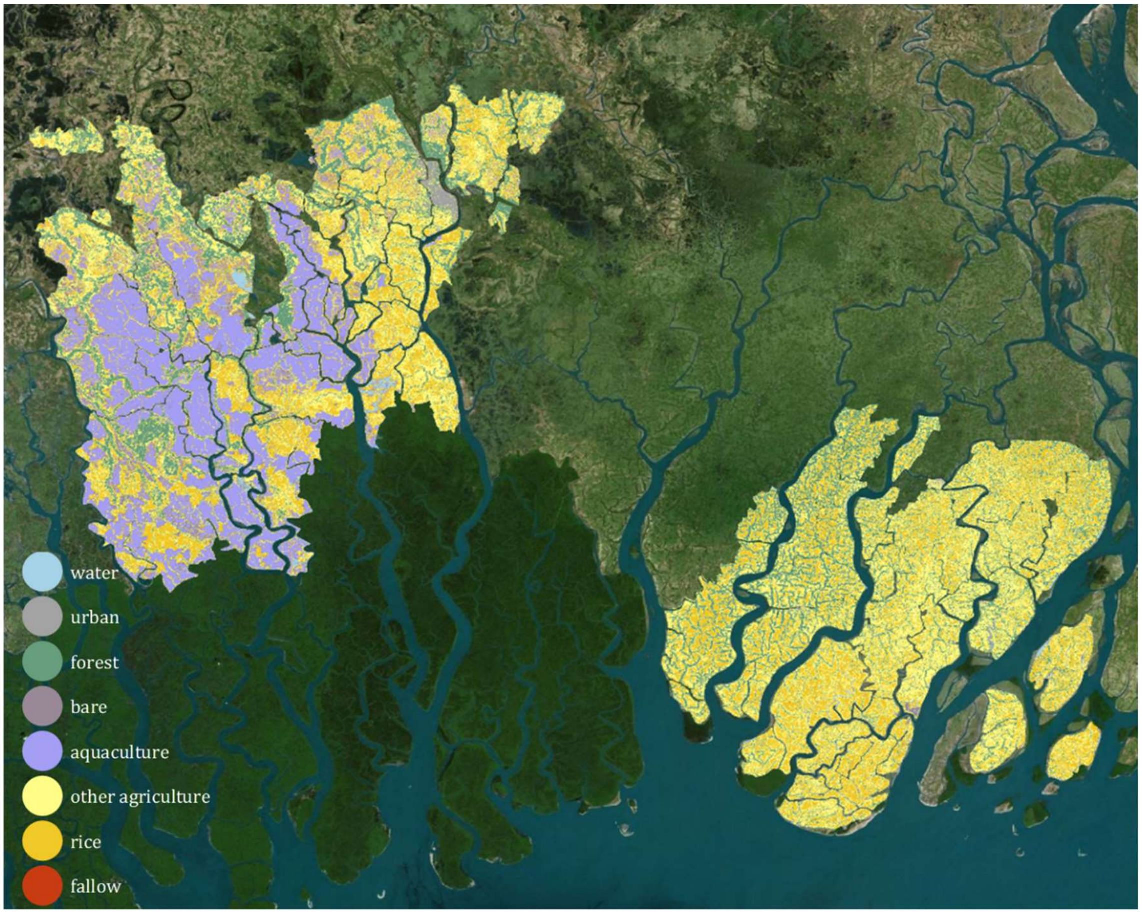

*Figure 8. Overall Land Use classification for 2017, created with aggregated Landsat and Sentinel-I imagery (Satelligence, 2019)*

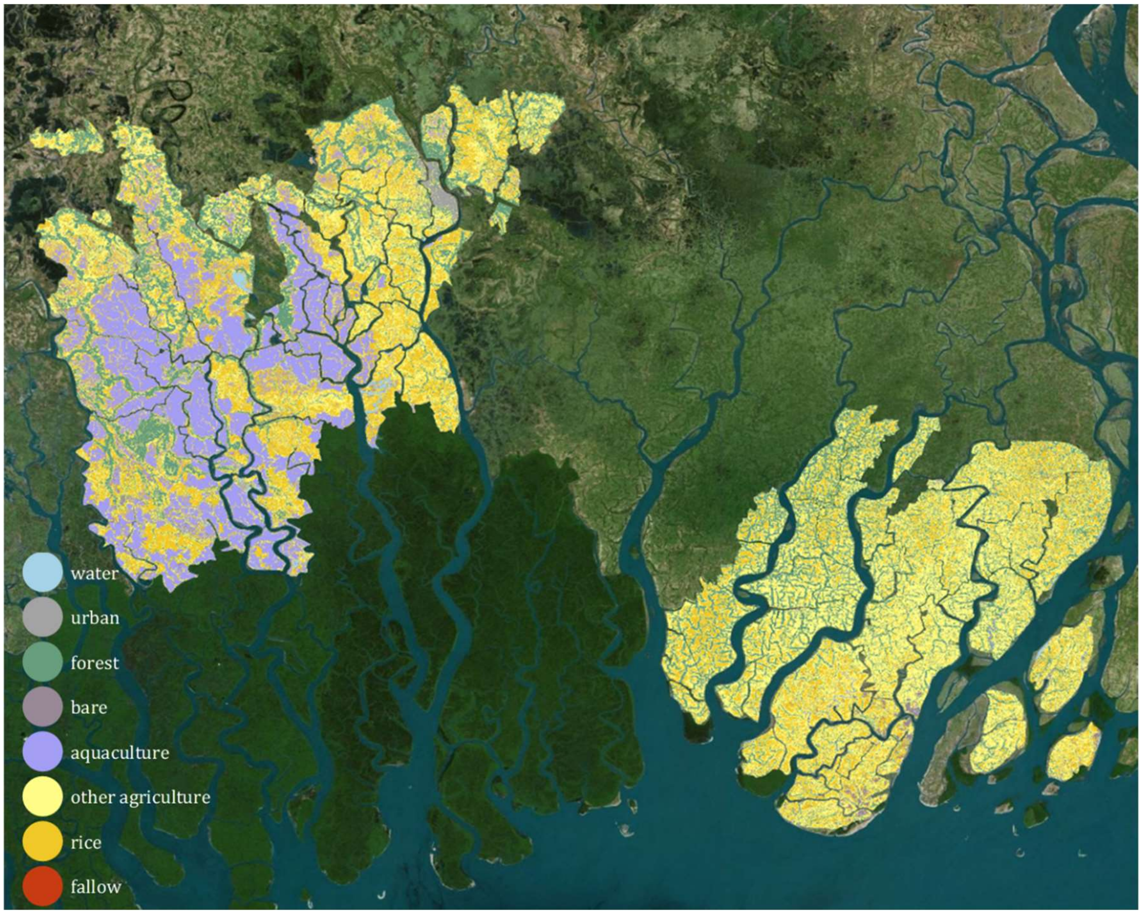

*Figure 9. Overall Land Use classification for 2018, created with aggregated Landsat and Sentinel-I imagery (Satelligence, 2019)*

The overall extent of agricultural land (cultivated area, rice and aquaculture combined) shows a variable pattern from the baseline to 2017 & 2018 (Table 2). Conventionally, changes are statistically significant with a p-value of <0.05. This is the case when comparing 2017 Rabi extent with the baseline, for both BGP and non-BGP polders. This means that the agricultural extent has extended significantly from the baseline to 2017, however, this is not the case for 2018. Other dominant trends were seen but these are all not significantly different, using the t-test methodology.
When we compare BGP polders with non-BGP polders no clear differences in land allocated for agriculture are observed.

Table 2. Significance test (t-test) for agricultural extent

| | **Rabi (agricultural extent)** | | **Kharif-I (agricultural extent)** | | **Kharif-II (agricultural extent)** | |
|---|---|---|---|---|---|---|
| | **Change agr. extent in %** | **P** | **Change agr. extent in %** | **P** | **Chang agr. extent in %** | **P** |
| All BGP polders 2017 vs All BGP polders baseline | 12.0 | 0.02 | -9.5 | 0.07 | 4.7 | 0.31 |
| All BGP polders 2018 vs All BGP polders baseline | -0.7 | 0.89 | 0.1 | 0.98 | 5.5 | 0.16 |
| All BGP polders 2017 vs All non-BGP polders 2017 | -2.7 | 0.44 | -2.3 | 0.63 | 0.82 | 0.02 |
| All BGP polders 2018 vs All non-BGP polders 2018 | 1.1 | 0.82 | -6.7 | 0.09 | 3.0 | 0.31 |
| All BGP polders baseline vs All non-BGP polders baseline | -4.4 | 0.23 | 3.0 | 0.48 | -0.8 | 0.81 |
| Non-BGP polders 2017 vs All non-BGP polders baseline | 10.2 | 0.01 | -4.3 | 0.16 | 3.1 | 0.18 |
| Non-BGP polders 2018 vs All non-BGP polders baseline | -6.3 | 0.03 | 9.74 | 0.01 | 1.6 | 0.47 |

Land use changes over time per polder can be displayed with the statistics data available (Appendix B). In most polders a slight increase in aquaculture and rice cultivation, and a subsequent decrease in other cultivated area, is observed. The total area used for agriculture remains stable, or increases slightly. The increase in rice cultivation occurs for most polders in all seasons (rabi, kharif-I and kharif-II). A significant number of polders had barely any rice cultivation for the baseline (2011-2015), but this increased on average 10 to 20 percent for most polders in 2017 & 2018.

The increase in rice cultivation is especially apparent in Barguna and Patuakhali. Polders in Khulna and Satkhira show more conversion to aquaculture; this is especially southern polders in these districts (see Appendix B).

## 4.2 Cropping intensity

Cropping intensity has increased significantly over the whole delta between het baseline and 2017 & 2018 (Figures 10-12). These images show harvests per year taking into account crops and aquaculture. Statistics are also given without aquaculture later this paragraph.

In Barguna and Patuakali, where during the baseline 1 harvest a year was measured, cropping intensity has increased to 2 or even 3 harvests a year. In Khulna and Satkhira, where during the baseline 1 to 2 harvests a year was measured, cropping intensity has slightly increased to 2 (and sometimes 3) harvests a year. The area used for cultivated area and rice has decreased here.


*Figure 10. Cropping intensity for the baseline, developed with aggregated Landsat imagery (Satelligence, 2019)*

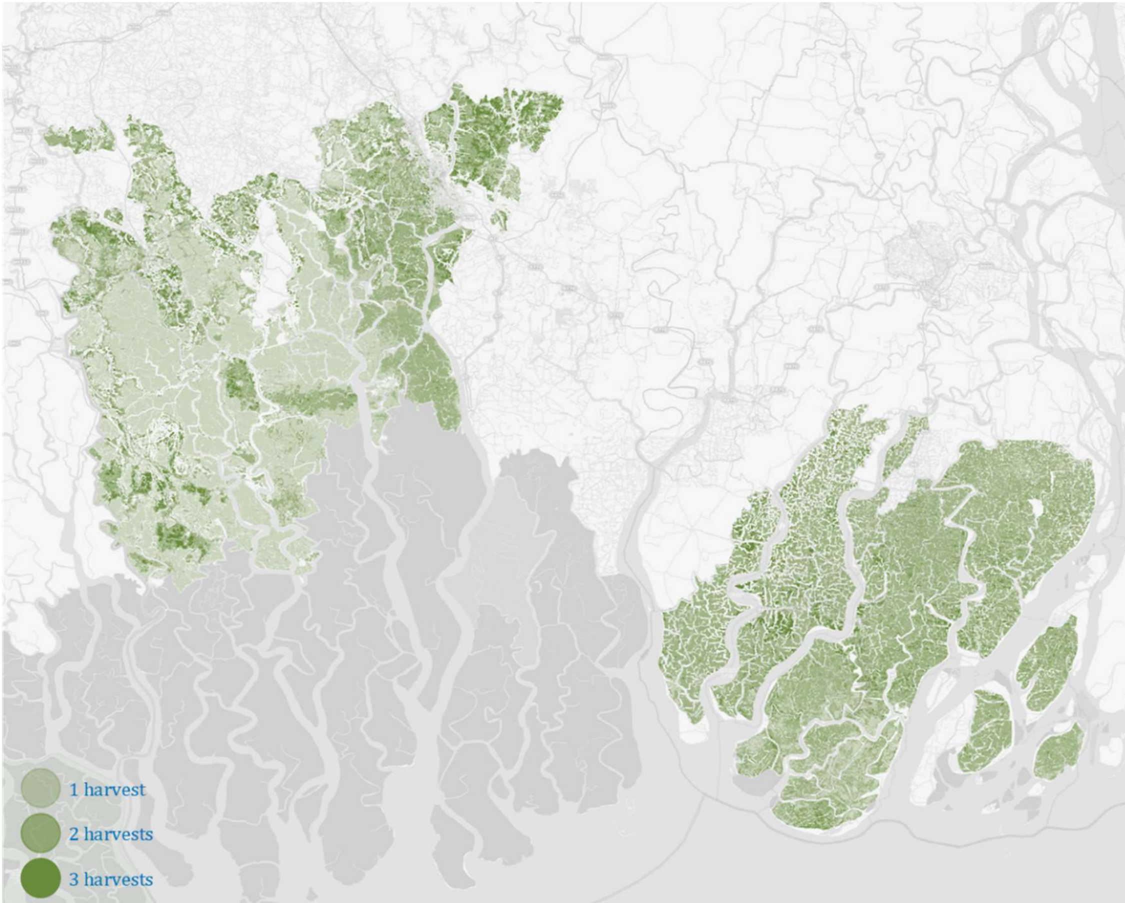

*Figure 11. Cropping intensity for 2017, developed with aggregated Landsat imagery (Satelligence, 2019)*

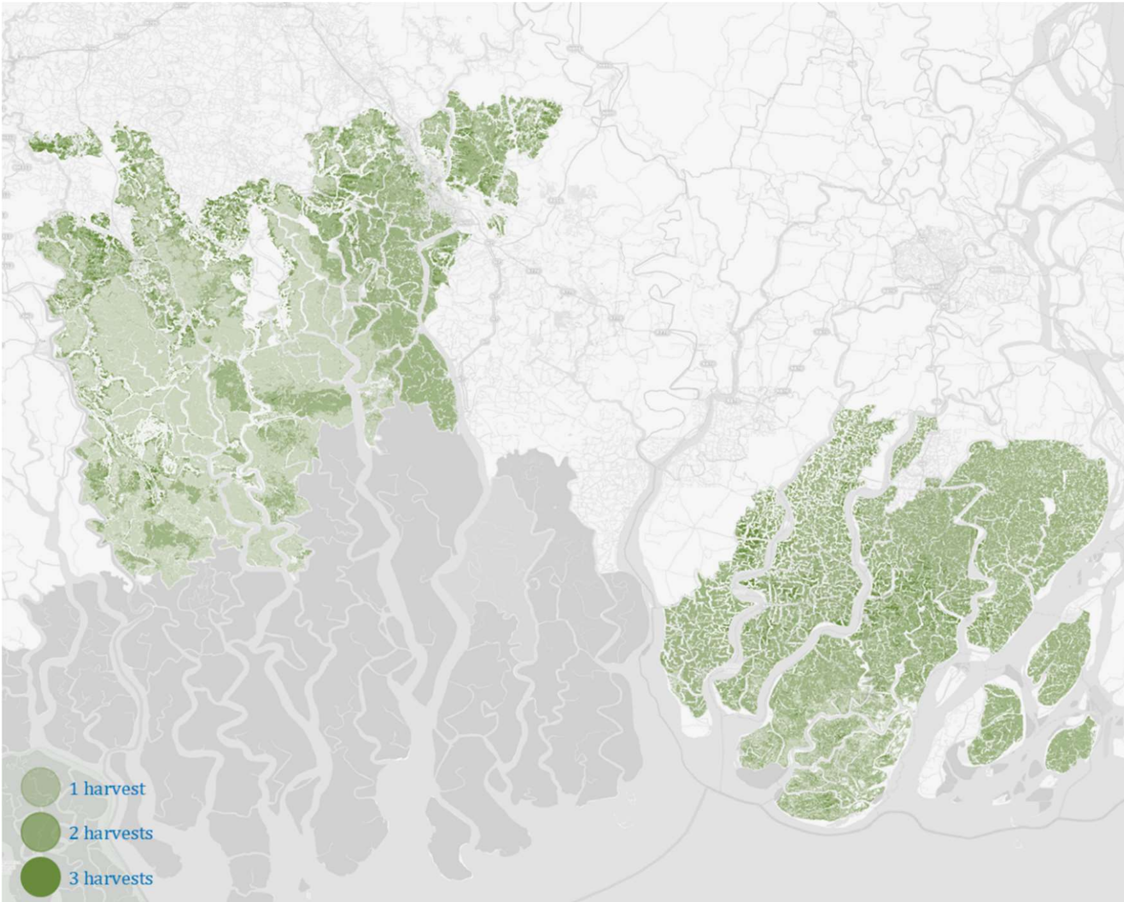


*Figure 12. Cropping intensity for 2018, developed with aggregated Landsat imagery (Satelligence, 2019)*

All the BGP polders show an increase in cropping intensity (Tables 3-4). Based on Cohen's d test we observe large positive changes for most BGP polders; only BGP polder 2 shows a medium increase in cropping intensity. Polders 43/1A & 43/2F show the largest increase in cropping intensity in 2017, with an average increase of 0.9 in cropping intensity. These polders still have a similar cropping intensity in 2018. Polder 26, however, shows the largest increase for this year, with an average increase of 1.0 in cropping intensity.

Change in cropping intensity from 2017 to 2018 are minimal (Table 5), with the largest increase being 0.2 for polders 25, 26 and 27/1, and the largest decrease being 0.2 for polder 2. Best performing polders in 2018 are 26, 27/1, 43/1A, 43/2A, 43/ 2B, 43/2F with a cropping intensity of 2.1. Worst performing polder in 2017 is 47/3 with a cropping intensity of 1.4.

Average change in BGP polders in cropping intensity from the baseline to 2017 is significant with 50% (1.29 vs 1.93). The average cropping intensity in 2018 is similar to 2017 with a value of 1.90. Changes between BGP and non-BGP polders are only small (cropping intensity of 1.29 vs 1.10 for the baseline; cropping intensity of 1.93 vs 1.80 for 2017; cropping intensity of 1.90 vs 1.80 for 2018). Cropping intensity results for non-BGP polders can be found in Appendix C.

Table 3. Significance test (Cohen's D test) for cropping intensity changes (with aquaculture) between 2017 and the baseline in BGP polders

| | **Area in km2** | **Baseline Mean** | **2017 mean** | **Change from baseline to 2017 (in absolute decimals)** | **Cohen's D** | **Effect Size** |
|---|---|---|---|---|---|---|
| All BGP polders baseline vs All non-BGP polders baseline | - | - | - | 0.1 | 1.5 | large |
| All BGP polder 2017 vs All BGP polders baseline | - | - | - | 0.6 | 4.0 | large |
| All BGP polders 2017 vs All non-BGP polders 2017 | - | - | - | 0.1 | 0.9 | large |
| All non-BGP polders 2017 vs All non-BGP polders baseline | - | - | - | 0.6 | 5.3 | large |
| Polder 2* | 127 | 1.3 | 1.8 | 0.5 | 0.7 | medium |
| Polder 22 | 15 | 1.2 | 1.9 | 0.6 | 1.6 | large |
| Polder 25 | 151 | 1.2 | 1.7 | 0.5 | 0.9 | large |
| Polder 26 | 27 | 1.1 | 1.9 | 0.8 | 1.8 | large |
| Polder 27/1 | 40 | 1.3 | 1.9 | 0.6 | 1.0 | large |
| Polder 27/2 | 8 | 1.0 | 1.8 | 0.8 | 1.2 | large |
| Polder 28/1 | 46 | 1.2 | 1.9 | 0.8 | 1.3 | large |
| Polder 28/2 | 21 | 1.5 | 2.1 | 0.6 | 1.4 | large |
| Polder 29 | 79 | 1.3 | 1.9 | 0.6 | 1.0 | large |
| Polder 30 | 65 | 1.7 | 2.1 | 0.4 | 0.9 | large |

| | | | | | | |
|---|---|---|---|---|---|---|
| Polder 31/ Part | 26 | 1.2 | 1.8 | 0.6 | 1.2 | large |
| Polder 34/2 Part | 49 | 1.4 | 2.1 | 0.7 | 1.2 | large |
| Polder 43/1A | 32 | 1.2 | 2.1 | 0.9 | 2.9 | large |
| Polder 43/2A | 47 | 1.4 | 2.0 | 0.6 | 2.4 | large |
| Polder 43/2B | 57 | 1.4 | 2.1 | 0.7 | 2.6 | large |
| Polder 43/2D | 81 | 1.4 | 2.1 | 0.6 | 2.4 | large |
| Polder 43/2E | 17 | 1.4 | 2.0 | 0.6 | 3.5 | large |
| Polder 43/2F | 42 | 1.2 | 2.2 | 0.9 | 2.8 | large |
| Polder 47/3 | 18 | 1.0 | 1.4 | 0.4 | 1.2 | large |
| Polder 47/4 | 68 | 1.0 | 1.6 | 0.6 | 1.4 | large |
| Polder 55/2A | 80 | 1.4 | 2.0 | 0.6 | 2.4 | large |
| Polder 55/2C | 64 | 1.5 | 2.1 | 0.7 | 2.1 | large |

In the Table above the cropping intensity for the BGP polders in 2017 is compared with the baseline (2011-2015). Data for non-BGP polders can be found in the data package to avoid data overload in the tables.

Table 4. Significance test (Cohen's D test) for cropping intensity changes (with aquaculture) between 2018 and the baseline in BGP polders

| | **Area in km2** | **Baseline Mean** | **2018 mean** | **Change from baseline to 2018 (in absolute decimals)** | **Cohen's D** | **Effect Size** |
|---|---|---|---|---|---|---|
| All BGP polder 2018 vs All BGP polders baseline | - | - | - | 0.7 | 4.8 | large |
| All BGP polders 2018 vs All non-BGP polders 2018 | - | - | - | 0.2 | 1.2 | large |
| All non-BGP polders 2018 vs All non-BGP polders baseline | - | 1.07 | 1.51 | 0.6 | 4.9 | large |
| Polder 2* | 127 | 1.3 | 1.6 | 0.3 | 0.5 | medium |
| Polder 22 | 15 | 1.2 | 2.0 | 0.7 | 2.4 | large |

| | | | | | | |
|---|---|---|---|---|---|---|
| Polder 25 | 151 | 1.2 | 1.9 | 0.7 | 1.2 | large |
| Polder 26 | 27 | 1.1 | 2.1 | 1.0 | 2.3 | large |
| Polder 27/1 | 40 | 1.3 | 2.1 | 0.8 | 1.8 | large |
| Polder 27/2 | 8 | 1.0 | 1.9 | 0.9 | 1.7 | large |
| Polder 28/1 | 46 | 1.2 | 1.9 | 0.8 | 1.6 | large |
| Polder 28/2 | 21 | 1.5 | 2.0 | 0.5 | 1.5 | large |
| Polder 29 | 79 | 1.3 | 1.9 | 0.6 | 1.1 | large |
| Polder 30 | 65 | 1.7 | 2.0 | 0.3 | 0.8 | large |
| Polder 31/ Part | 26 | 1.2 | 1.8 | 0.6 | 1.4 | large |
| Polder 34/2 Part | 49 | 1.4 | 2.0 | 0.6 | 1.3 | large |
| Polder 43/1A | 32 | 1.2 | 2.1 | 0.9 | 2.3 | large |
| Polder 43/2A | 47 | 1.4 | 2.1 | 0.6 | 2.2 | large |
| Polder 43/2B | 57 | 1.4 | 2.1 | 0.7 | 2.5 | large |
| Polder 43/2D | 81 | 1.4 | 2.0 | 0.6 | 2.5 | large |
| Polder 43/2E | 17 | 1.4 | 2.0 | 0.6 | 2.5 | large |
| Polder 43/2F | 42 | 1.2 | 2.1 | 0.9 | 2.9 | large |
| Polder 47/3 | 18 | 1.0 | 1.4 | 0.4 | 1.0 | large |
| Polder 47/4 | 68 | 1.0 | 1.7 | 0.6 | 1.4 | large |
| Polder 55/2A | 80 | 1.4 | 2.0 | 0.6 | 2.7 | large |
| Polder 55/2C | 64 | 1.5 | 2.0 | 0.6 | 2.3 | large |

In the Table above the cropping intensity for the BGP polders in 2018 is compared with the baseline (2011-2015). Data for non-BGP polders can be found in the data package to avoid data overload in the tables.

Table 5. Comparison in cropping intensity changes (with aquaculture) between 2018 and 2017 for BGP polders

| | Area in km2 | 2017 mean | 2018 mean | Change from 2017 to 2018 (in absolute decimals) |
|---|---|---|---|---|
| Polder 2* | 127 | 1.8 | 1.6 | -0.2 |
| Polder 22 | 15 | 1.9 | 2.0 | 0.1 |
| Polder 25 | 151 | 1.7 | 1.9 | 0.2 |
| Polder 26 | 27 | 1.9 | 2.1 | 0.2 |
| Polder 27/1 | 40 | 1.9 | 2.1 | 0.2 |
| Polder 27/2 | 8 | 1.8 | 1.9 | 0.1 |
| Polder 28/1 | 46 | 1.9 | 1.9 | - |
| Polder 28/2 | 21 | 2.1 | 2.0 | -0.1 |
| Polder 29 | 79 | 1.9 | 1.9 | - |
| Polder 30 | 65 | 2.1 | 2.0 | -0.1 |
| Polder 31/ Part | 26 | 1.8 | 1.8 | - |
| Polder 34/2 Part | 49 | 2.1 | 2.0 | -0.1 |
| Polder 43/1A | 32 | 2.1 | 2.1 | - |
| Polder 43/2A | 47 | 2.0 | 2.1 | 0.1 |
| Polder 43/2B | 57 | 2.1 | 2.1 | - |
| Polder 43/2D | 81 | 2.1 | 2.0 | -0.1 |
| Polder 43/2E | 17 | 2.0 | 2.0 | - |
| Polder 43/2F | 42 | 2.2 | 2.1 | -0.1 |
| Polder 47/3 | 18 | 1.4 | 1.4 | - |
| Polder 47/4 | 68 | 1.6 | 1.7 | 0.1 |
| Polder 55/2A | 80 | 2.0 | 2.0 | - |
| Polder 55/2C | 64 | 2.1 | 2.0 | -0.1 |

Alternatively, one can look to cropping intensity without aquaculture. Below (Tables 6-7) the results of analysis without aquaculture are given. For most of the BGP polders there are no significant differences compared to the method with aquaculture.

Table 6. Significance test (Cohen's D test) for cropping intensity changes (without aquaculture) between 2017 and the baseline in BGP polders

| | Area in km2 | Baseline Mean | 2017 mean | Change from baseline to 2017 (in absolute decimals) | Cohen's D | Effect Size |
|---|---|---|---|---|---|---|
| All BGP polders baseline vs All non-BGP polders baseline | - | - | - | 0.2 | 1.5 | large |
| All BGP polder 2017 vs All BGP polders baseline | - | - | - | 0.7 | 4.2 | large |
| All BGP polders 2017 vs All non-BGP polders 2017 | - | - | - | 0.1 | 0.6 | medium |
| All non-BGP polders 2017 vs All non-BGP polders baseline | - | - | - | 0.8 | 5.1 | large |
| Polder 2* | 127 | 1.4 | 2.1 | 0.7 | 1.0 | large |
| Polder 22 | 15 | 1.2 | 1.9 | 0.6 | 1.6 | large |
| Polder 25 | 151 | 1.2 | 1.8 | 0.7 | 1.1 | large |
| Polder 26 | 27 | 1.1 | 2.0 | 0.9 | 2.0 | large |
| Polder 27/1 | 40 | 1.3 | 1.9 | 0.6 | 1.1 | large |
| Polder 27/2 | 8 | 1.0 | 1.9 | 0.9 | 1.4 | large |
| Polder 28/1 | 46 | 1.2 | 2.0 | 0.8 | 1.4 | large |
| Polder 28/2 | 21 | 1.5 | 2.1 | 0.6 | 1.4 | large |
| Polder 29 | 79 | 1.4 | 1.9 | 0.6 | 1.0 | large |
| Polder 30 | 65 | 1.7 | 2.1 | 0.4 | 0.9 | large |
| Polder 31/ Part | 26 | 1.2 | 1.9 | 0.7 | 1.4 | large |
| Polder 34/2 Part | 49 | 1.4 | 2.1 | 0.7 | 1.3 | large |

| | | | | | | |
|---|---|---|---|---|---|---|
| Polder 43/1A | 32 | 1.2 | 2.1 | 0.9 | 2.9 | large |
| Polder 43/2A | 47 | 1.4 | 2.0 | 0.6 | 2.4 | large |
| Polder 43/2B | 57 | 1.4 | 2.1 | 0.7 | 2.6 | large |
| Polder 43/2D | 81 | 1.4 | 2.1 | 0.6 | 2.4 | large |
| Polder 43/2E | 17 | 1.4 | 2.0 | 0.6 | 3.5 | large |
| Polder 43/2F | 42 | 1.2 | 2.2 | 0.9 | 2.8 | large |
| Polder 47/3 | 18 | 1.0 | 1.4 | 0.4 | 1.2 | large |
| Polder 47/4 | 68 | 1.0 | 1.6 | 0.6 | 1.4 | large |
| Polder 55/2A | 80 | 1.4 | 2.0 | 0.6 | 2.4 | large |
| Polder 55/2C | 64 | 1.5 | 2.1 | 0.7 | 2.1 | large |

In the Table above the cropping intensity for the BGP polders in 2017 is compared with the baseline (2011-2015). Data for non-BGP polders can be found in the data package to avoid data overload in the tables.

Table 7. Significance test (Cohen's D test) for cropping intensity changes (without aquaculture) between 2018 and the baseline in BGP polders

| | **Area in km2** | **Baseline Mean** | **2018 mean** | **Change from baseline to 2018 (in absolute decimals)** | **Cohen's D** | **Effect Size** |
|---|---|---|---|---|---|---|
| All BGP polder 2018 vs All BGP polders baseline | - | - | - | 0.7 | 5.0 | large |
| All BGP polders 2018 vs All non-BGP polders 2018 | - | - | - | 0.1 | 0.8 | medium |
| All non-BGP polders 2018 vs All non-BGP polders baseline | - | - | - | 0.7 | 4.4 | large |
| Polder 2* | 127 | 1.4 | 1.9 | 0.5 | 0.8 | medium |
| Polder 22 | 15 | 1.2 | 2.0 | 0.7 | 2.4 | large |
| Polder 25 | 151 | 1.2 | 2.0 | 0.8 | 1.4 | large |
| Polder 26 | 27 | 1.1 | 2.1 | 1.0 | 2.3 | large |

| | | | | | | |
|---|---|---|---|---|---|---|
| Polder 27/1 | 40 | 1.3 | 2.2 | 0.9 | 1.9 | large |
| Polder 27/2 | 8 | 1.0 | 2.0 | 1.0 | 1.9 | large |
| Polder 28/1 | 46 | 1.2 | 2.0 | 0.8 | 1.6 | large |
| Polder 28/2 | 21 | 1.5 | 2.0 | 0.5 | 1.6 | large |
| Polder 29 | 79 | 1.4 | 1.9 | 0.6 | 1.1 | large |
| Polder 30 | 65 | 1.7 | 2.0 | 0.3 | 0.8 | large |
| Polder 31/ Part | 26 | 1.2 | 1.9 | 0.7 | 1.6 | large |
| Polder 34/2 Part | 49 | 1.4 | 2.0 | 0.6 | 1.4 | large |
| Polder 43/1A | 32 | 1.2 | 2.1 | 0.9 | 2.4 | large |
| Polder 43/2A | 47 | 1.4 | 2.1 | 0.6 | 2.2 | large |
| Polder 43/2B | 57 | 1.4 | 2.1 | 0.7 | 2.5 | large |
| Polder 43/2D | 81 | 1.4 | 2.0 | 0.6 | 2.5 | large |
| Polder 43/2E | 17 | 1.4 | 2.0 | 0.6 | 2.5 | large |
| Polder 43/2F | 42 | 1.2 | 2.1 | 0.9 | 2.9 | large |
| Polder 47/3 | 18 | 1.0 | 1.4 | 0.4 | 1.0 | large |
| Polder 47/4 | 68 | 1.0 | 1.7 | 0.6 | 1.4 | large |
| Polder 55/2A | 80 | 1.4 | 2.0 | 0.6 | 2.7 | large |
| Polder 55/2C | 64 | 1.5 | 2.0 | 0.6 | 2.3 | large |

In the Table above the cropping intensity for the BGP polders in 2018 is compared with the baseline (2011-2015). Data for non-BGP polders can be found in the data package to avoid data overload in the tables.

## 4.3 Cropping intensity comparison with WMG data

Technical report 25 *Improving the Productivity of Land in the Coastal Bangladesh: The Outcomes of Blue Gold Program Interventions*, compares the Satelligence MTR data with the WMG survey data for all BGP polders. Below we compare results for each polder based on Satelligence's FR. Satelligence's method comes closest to Method A of Technical Report which is calculated as *crops + gher / (crops + gher + fallow)*.

Table 8. Estimation of cropping intensity changes in the Khulna zone

| Polder | WMG Baseline | WMG 2017 | Satelligence Baseline | Satelligence 2017 | Change in c.i. WMG | Change in c.i. Satelligence |
|---|---|---|---|---|---|---|
| 22 | 128.8 | 177.6 | 120.0 | 190.0 | 48.8 | 58.3 |
| 26 | 173.9 | 251.3 | 110.0 | 190.0 | 77.4 | 72.2 |
| 29 | 197.8 | 245.5 | 130.0 | 190.0 | 47.7 | 46.2 |
| 30 | 170.4 | 172.9 | 170.0 | 210.0 | 2.5 | 23.5 |
| 31-BGP | 172 | 209 | 120.0 | 180.0 | 37.0 | 50.0 |

Table 9. Estimation of cropping intensity changes in the Satkhira zone

| Polder | WMG Baseline | WMG 2017 | Satelligence Baseline | Satelligence 2017 | Change in c.i. WMG | Change in c.i. Satelligence |
|---|---|---|---|---|---|---|
| 2 | 141.0 | 172.0 | 130 | 180 | 31.0 | 38.5 |

Table 10. Estimation of cropping intensity changes in the Patuakhali zone

| Polder | WMG Baseline | WMG 2017 | Satelligence Baseline | Satelligence 2017 | Change in c.i. WMG | Change in c.i. Satelligence |
|---|---|---|---|---|---|---|
| 43-1A | 205.4 | 241.1 | 120 | 210 | 35.7 | 75.0 |
| 43-2A | 184.7 | 216.9 | 140 | 200 | 32.2 | 42.9 |
| 43-2B | 155.0 | 204.0 | 140 | 210 | 49.0 | 50.0 |
| 43-2D | 176.6 | 217.8 | 140 | 210 | 41.2 | 50.0 |
| 43-2E | 166.3 | 207.1 | 140 | 200 | 40.8 | 42.9 |
| 43-2F | 194.3 | 233.7 | 120 | 220 | 39.4 | 83.3 |
| 55-2A | 183.8 | 205.4 | 140 | 200 | 21.5 | 42.9 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 55-2C | 183.8 | 203.9 | 150 | 210 | 20.0 | 40.0 |

Satelligence relative changes in cropping intensity are comparable to WMG survey data for most polders. A major difference is that often the baseline of Satelligence data is lower than for the WMG survey. This is likely due to the fact that the Satelligence baseline is the average over multiple years (2011-2015) versus a snapshot in time for WMG survey data.

Polders 26 and 29 have significantly higher cropping intensity in the WMG survey data than in the Satelligence data. This could either mean that gher contribution is overestimated in WMG survey data, or underestimated in Satelligence analysis.

# 5. Discussion

## 5.1 Main drivers of increase in cropping intensity

Land use in the coastal Bangladesh is diverse, competitive and conflicting. Over the last half-century coastal land uses of Bangladesh have gone through major changes. Since the 1950s, natural disasters such as cyclone and tidal flooding, salinity intrusion, large-scale polderization and intensive shrimp farming have changed the whole coastal area of Bangladesh. These changes are especially prominent in the southwestern coastal belt (Parvin et al., 2017).

From the 1990's until 2010 both the agricultural land as shrimp area (aquaculture) has decreased significantly, mainly in favor of 'settlements with homestead forest' (Parvin et al., 2017). One of the goals of BGP goals is to increase productivity. The agricultural extent has barely changed during the course of the program, so far. Although the agricultural extent has not increased, the upside is that the historically observed decrease in agricultural area seems to be ceased. Additionally, the change in cropping intensity from the baseline to 2017 & 2018 is around significant, (~50%). This means highly likely that more fallow land is cultivated after BGP interventions for each of the seasons. It seems that in the whole Bangladesh delta, regional interventions and farmer practices have improved, so that farmers can grow crops in more additional seasons. Conversion of crops to aquaculture is relatively higher for Khulna and Satkhira than for Patuakhali and Barguna; this is especially the case for fields which showed only one harvest a year for the baseline. In our analysis we have defined cropping intensity by including both crops and aquaculture so that all land used by smallholders is included in the analysis.

BGP is also interested in agricultural diversification in the polders. Comparing changes in use of agricultural land from the baseline to 2017 & 2018, it seems that there is a small conversion from other cultivated area to rice and aquaculture. Based on BGP's own farmer-level impact surveys, farmers have reported that higher rice prices have encouraged increased rice production. This trend has not changed significantly between 2017 and 2018.

## 5.2 Agricultural extent: distinguishing cultivated area from fallow

Our results show a significant increase in cropping intensity. With an increase in cropping intensity one would expect to see an increase in agricultural extent. However, only a small increase in agricultural extent is observed. The analysis of cropping intensity, based on NDVI, is very robust and accurate. Therefore, the fact that the agricultural extent has not changed significantly between the baseline and 2017 & 2018 is most likely due to the fact that more land that was fallow during the baseline is being cultivated in 2017 & 2018.

Especially the western part of the delta (Barguna and Patuakhali) is known to have significant fallow land; dominantly during the Rabi season (Bangladesh Country Almanac, 2006). A significant conversion of this fallow land to rice cultivation in 2017 & 2018 has been observed, which is also translated in the increase in cropping intensity.

### 5.3 Trends in Aquaculture

Aquaculture classification was investigated by Satelligence, upon request of the BGP Monitoring Reflection and Learning Team. BGP is interested in aquaculture because a significant number of smallholders changed their agricultural practices from perennial crops to aquaculture in recent years. From 2000 to 2016, aquaculture production has more than doubled in Bangladesh because of improved techniques and expansion of (inland) aquaculture area (Shamsuzzaman et al., 2017).

Aquaculture testing seemed to be successful and has been included as a land-use class. The mapped aquaculture ponds are the 'inland closed water fisheries' (locally also known as ghers), and need to have a minimum size of 30x30m (see 'Methodology of Analysis').

Please note that:

- fields with mixed rice and aquaculture practice (e.g. rice with shrimps) are classified as rice;
- the average size of ghers differs significantly per district (Belton et al., 2011). Therefore, aquaculture is underestimated in districts where small ponds are common. Making use of high-resolution imagery the smaller ponds appear to be in Barguna and Patuakhali, which is consistent with available literature. Therefore, significant underestimations are expected in those two districts;
- the fisheries sector in Bangladesh is broadly divided into three sub-sectors: inland op water (capture) fishery, inland closed water (culture) fishery and marine fisheries (DoF, 2016). The mapped aquaculture are the inland closed water fisheries; inland open water fishery and marine fishery are not included. Open water is classified as 'water'. It is not possible to see from space if open water bodies (e.g. lakes) are used for fishery or not.

Results show an increase in ghers from the baseline to 2017 & 2018, mainly in Khulna and Satkhira. To make sure that most of the water bodies identified are aquaculture, and this change to aquaculture is persistent, information for more years (e.g. 2018) and more field data is needed. The variation seems to be quite high for some of the polders. Questions arise such as: is this increase due to an extreme wet outlier (World Weather Online, 2018), increased salinization (IWMI, 2014), or is the change to aquaculture on a consistent basis?

The importance of aquaculture in the BGP area should not be overstated, as the fraction of ghers in most BGP polders are relatively low. Polder 2 shows the largest percentage aquaculture of all BGP polders, with a maximum of 18% throughout the tested years. Other (non-BGP) polders show much higher percentages aquaculture (e.g. polder 16).

## 6. Conclusions

Land use has extensively changed over the last few decades in the polder areas of Bangladesh. These major changes have continued over the course of this decade as highlighted in this report. Some of the major findings:

- Cropping intensity has increased significantly for most polders due to improved farmer practices and regional interventions. Overall the increase has been ~50% between the baseline and 2017 & 2018.
- There is no significant difference between 2017 and 2018 in cropping intensity.
- Major increase in cropping intensity is observed all four districts.
- The agricultural extent remained more or less the same from the baseline (2011-2015) to 2017 & 2018 for most polders.
- Agricultural land use slightly converted from other cultivated area to rice and aquaculture. This could be due to 1) 2017 & 2018 being wetter years than normal, 2) salinization, 3) change in farmer practices, or 4) crop prices.
- Aquaculture (defined as inland closed water fisheries) can be seen from space based on trend-analysis. Increase in aquaculture is mainly observed in Khulna and Satkhira.

# 7. References

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## Appendix A. Data package

The data package can be found through the WeTransfer link provided and consists of a

- Fielddata map, which contains all the field data collected for calibration and validation
- Geodata map, which contains maps and statistics for 1) the land use and land cover changes, and 2) the cropping intensity (including and excluding aquaculture)
- Polders Shapefile map: Includes the shapefiles used during the analyses
- FR_S11_EO4ME: This Final Report

For more information or if you have any questions, please contact tolsma@satelligence.com

## Appendix B. Land use distribution BGP polders

Below the agricultural land use per season per polder (in decimals) for all the BGP polders are described. The other land uses are left out for visualization purposes but can be found in the data package. All land uses combined (including the non-agriculture land use classes left out below) will give a decimal value of 1.0.

| Polder 2 | Aquaculture | Other agriculture | Rice | Fallow |
|---|---|---|---|---|
| Rabi Baseline | 0.16 | 0.28 | 0.18 | 0.03 |
| Rabi 2017 | 0.17 | 0.26 | 0.16 | 0.02 |
| Rabi 2018 | 0.18 | 0.23 | 0.19 | 0.05 |
| Kharif-I Baseline | 0.16 | 0.07 | 0.02 | 0.40 |
| Kharif-I 2017 | 0.17 | 0.11 | 0.06 | 0.27 |
| Kharif-I 2018 | 0.18 | 0.08 | 0.03 | 0.37 |
| Kharif-II Baseline | 0.16 | 0.26 | 0.10 | 0.13 |
| Kharif-II 2017 | 0.17 | 0.23 | 0.10 | 0.11 |
| Kharif-II 2018 | 0.18 | 0.24 | 0.13 | 0.11 |

| Polder 22 | Aquaculture | Other agriculture | Rice | Fallow |
|---|---|---|---|---|
| Rabi Baseline | 0.00 | 0.17 | 0.00 | 0.70 |
| Rabi 2017 | 0.00 | 0.12 | 0.03 | 0.75 |
| Rabi 2018 | 0.00 | 0.02 | 0.00 | 0.85 |
| Kharif-I Baseline | 0.00 | 0.73 | 0.03 | 0.11 |
| Kharif-I 2017 | 0.00 | 0.34 | 0.28 | 0.28 |
| Kharif-I 2018 | 0.00 | 0.51 | 0.31 | 0.05 |
| Kharif-II Baseline | 0.00 | 0.83 | 0.04 | 0.00 |

| | | | | |
|---|---|---|---|---|
| Kharif-II 2017 | 0.00 | 0.54 | 0.36 | 0.00 |
| Kharif-II 2018 | 0.00 | 0.55 | 0.33 | 0.00 |

| **Polder 25** | **Aquaculture** | **Other agriculture** | **Rice** | **Fallow** |
|---|---|---|---|---|
| Rabi Baseline | 0.08 | 0.26 | 0.20 | 0.03 |
| Rabi 2017 | 0.10 | 0.25 | 0.23 | 0.02 |
| Rabi 2018 | 0.07 | 0.25 | 0.25 | 0.03 |
| Kharif-I Baseline | 0.08 | 0.10 | 0.06 | 0.33 |
| Kharif-I 2017 | 0.10 | 0.08 | 0.05 | 0.38 |
| Kharif-I 2018 | 0.07 | 0.09 | 0.06 | 0.38 |
| Kharif-II Baseline | 0.08 | 0.19 | 0.09 | 0.21 |
| Kharif-II 2017 | 0.10 | 0.22 | 0.10 | 0.18 |
| Kharif-II 2018 | 0.07 | 0.25 | 0.15 | 0.13 |

| **Polder 26** | **Aquaculture** | **Other agriculture** | **Rice** | **Fallow** |
|---|---|---|---|---|
| Rabi Baseline | 0.02 | 0.36 | 0.10 | 0.26 |
| Rabi 2017 | 0.04 | 0.36 | 0.20 | 0.14 |
| Rabi 2018 | 0.01 | 0.40 | 0.26 | 0.11 |
| Kharif-I Baseline | 0.02 | 0.28 | 0.01 | 0.43 |
| Kharif-I 2017 | 0.04 | 0.11 | 0.08 | 0.52 |
| Kharif-I 2018 | 0.01 | 0.17 | 0.07 | 0.54 |
| Kharif-II Baseline | 0.02 | 0.58 | 0.07 | 0.07 |
| Kharif-II 2017 | 0.04 | 0.42 | 0.22 | 0.07 |
| Kharif-II 2018 | 0.01 | 0.47 | 0.26 | 0.05 |

| Polder 27/1 | Aquaculture | Other agriculture | Rice | Fallow |
|---|---|---|---|---|
| Rabi Baseline | 0.05 | 0.40 | 0.26 | 0.03 |
| Rabi 2017 | 0.05 | 0.41 | 0.31 | 0.01 |
| Rabi 2018 | 0.03 | 0.41 | 0.33 | 0.01 |
| Kharif-I Baseline | 0.05 | 0.19 | 0.10 | 0.40 |
| Kharif-I 2017 | 0.05 | 0.15 | 0.09 | 0.48 |
| Kharif-I 2018 | 0.03 | 0.13 | 0.10 | 0.53 |
| Kharif-II Baseline | 0.05 | 0.28 | 0.09 | 0.32 |
| Kharif-II 2017 | 0.05 | 0.32 | 0.12 | 0.29 |
| Kharif-II 2018 | 0.03 | 0.40 | 0.26 | 0.09 |

| Polder 27/2 | Aquaculture | Other agriculture | Rice | Fallow |
| --- | --- | --- | --- | --- |
| Rabi Baseline | 0.07 | 0.27 | 0.18 | 0.15 |
| Rabi 2017 | 0.08 | 0.31 | 0.22 | 0.08 |
| Rabi 2018 | 0.05 | 0.35 | 0.29 | 0.05 |
| Kharif-I Baseline | 0.07 | 0.14 | 0.03 | 0.44 |
| Kharif-I 2017 | 0.08 | 0.21 | 0.07 | 0.34 |
| Kharif-I 2018 | 0.05 | 0.10 | 0.06 | 0.53 |
| Kharif-II Baseline | 0.07 | 0.29 | 0.05 | 0.26 |
| Kharif-II 2017 | 0.08 | 0.30 | 0.07 | 0.25 |
| Kharif-II 2018 | 0.05 | 0.36 | 0.20 | 0.13 |

| Polder 28/1 | Aquaculture | Other agriculture | Rice | Fallow |
| --- | --- | --- | --- | --- |
| Rabi Baseline | 0.07 | 0.33 | 0.24 | 0.06 |
| Rabi 2017 | 0.07 | 0.36 | 0.27 | 0.04 |
| Rabi 2018 | 0.04 | 0.36 | 0.30 | 0.07 |
| Kharif-I Baseline | 0.07 | 0.18 | 0.07 | 0.38 |
| Kharif-I 2017 | 0.07 | 0.23 | 0.13 | 0.30 |
| Kharif-I 2018 | 0.04 | 0.12 | 0.08 | 0.53 |
| Kharif-II Baseline | 0.07 | 0.28 | 0.06 | 0.29 |
| Kharif-II 2017 | 0.07 | 0.30 | 0.07 | 0.30 |
| Kharif-II 2018 | 0.04 | 0.39 | 0.19 | 0.15 |

| Polder 28/2 | Aquaculture | Other agriculture | Rice | Fallow |
| --- | --- | --- | --- | --- |
| Rabi Baseline | 0.00 | 0.19 | 0.02 | 0.45 |

| | | | | |
|---|---|---|---|---|
| Rabi 2017 | 0.00 | 0.26 | 0.09 | 0.36 |
| Rabi 2018 | 0.00 | 0.10 | 0.03 | 0.56 |
| Kharif-I Baseline | 0.00 | 0.54 | 0.02 | 0.08 |
| Kharif-I 2017 | 0.00 | 0.35 | 0.12 | 0.25 |
| Kharif-I 2018 | 0.00 | 0.43 | 0.14 | 0.12 |
| Kharif-II Baseline | 0.00 | 0.61 | 0.03 | 0.00 |
| Kharif-II 2017 | 0.00 | 0.53 | 0.18 | 0.00 |
| Kharif-II 2018 | 0.00 | 0.52 | 0.16 | 0.00 |

| **Polder 29** | **Aquaculture** | **Other agriculture** | **Rice** | **Fallow** |
|---|---|---|---|---|
| Rabi Baseline | 0.02 | 0.30 | 0.06 | 0.33 |
| Rabi 2017 | 0.03 | 0.32 | 0.10 | 0.27 |
| Rabi 2018 | 0.03 | 0.32 | 0.15 | 0.25 |
| Kharif-I Baseline | 0.02 | 0.28 | 0.01 | 0.40 |
| Kharif-I 2017 | 0.03 | 0.23 | 0.06 | 0.41 |
| Kharif-I 2018 | 0.03 | 0.17 | 0.07 | 0.48 |
| Kharif-II Baseline | 0.02 | 0.56 | 0.09 | 0.05 |
| Kharif-II 2017 | 0.03 | 0.47 | 0.18 | 0.05 |
| Kharif-II 2018 | 0.03 | 0.45 | 0.24 | 0.03 |

| **Polder 30** | **Aquaculture** | **Other agriculture** | **Rice** | **Fallow** |
|---|---|---|---|---|
| Rabi Baseline | 0.00 | 0.11 | 0.01 | 0.66 |
| Rabi 2017 | 0.00 | 0.21 | 0.11 | 0.52 |
| Rabi 2018 | 0.00 | 0.08 | 0.05 | 0.68 |
| Kharif-I Baseline | 0.00 | 0.70 | 0.04 | 0.03 |

| | | | | |
|---|---|---|---|---|
| Kharif-I 2017 | 0.00 | 0.36 | 0.25 | 0.22 |
| Kharif-I 2018 | 0.00 | 0.40 | 0.29 | 0.12 |
| Kharif-II Baseline | 0.00 | 0.73 | 0.04 | 0.00 |
| Kharif-II 2017 | 0.00 | 0.51 | 0.32 | 0.00 |
| Kharif-II 2018 | 0.00 | 0.47 | 0.34 | 0.00 |

| Polder 31/Part | Aquaculture | Other agriculture | Rice | Fallow |
|---|---|---|---|---|
| Rabi Baseline | 0.05 | 0.13 | 0.01 | 0.61 |
| Rabi 2017 | 0.07 | 0.14 | 0.08 | 0.53 |
| Rabi 2018 | 0.07 | 0.12 | 0.09 | 0.54 |
| Kharif-I Baseline | 0.05 | 0.55 | 0.03 | 0.17 |
| Kharif-I 2017 | 0.07 | 0.17 | 0.27 | 0.32 |
| Kharif-I 2018 | 0.07 | 0.22 | 0.25 | 0.29 |
| Kharif-II Baseline | 0.05 | 0.66 | 0.08 | 0.01 |
| Kharif-II 2017 | 0.07 | 0.33 | 0.41 | 0.01 |
| Kharif-II 2018 | 0.07 | 0.35 | 0.40 | 0.00 |

| Polder 34/2 Part | Aquaculture | Other agriculture | Rice | Fallow |
|---|---|---|---|---|
| Rabi Baseline | 0.01 | 0.28 | 0.06 | 0.36 |
| Rabi 2017 | 0.03 | 0.25 | 0.22 | 0.25 |
| Rabi 2018 | 0.02 | 0.23 | 0.23 | 0.26 |
| Kharif-I Baseline | 0.01 | 0.30 | 0.06 | 0.34 |
| Kharif-I 2017 | 0.03 | 0.18 | 0.15 | 0.40 |
| Kharif-I 2018 | 0.02 | 0.11 | 0.19 | 0.42 |

| | | | | |
|---|---|---|---|---|
| Kharif-II Baseline | 0.01 | 0.55 | 0.15 | 0.00 |
| Kharif-II 2017 | 0.03 | 0.36 | 0.37 | 0.00 |
| Kharif-II 2018 | 0.02 | 0.31 | 0.40 | 0.00 |

| **Polder 43/1A** | **Aquaculture** | **Other agriculture** | **Rice** | **Fallow** |
|---|---|---|---|---|
| Rabi Baseline | 0.00 | 0.51 | 0.05 | 0.20 |
| Rabi 2017 | 0.00 | 0.51 | 0.20 | 0.11 |
| Rabi 2018 | 0.00 | 0.39 | 0.08 | 0.31 |
| Kharif-I Baseline | 0.00 | 0.30 | 0.02 | 0.44 |
| Kharif-I 2017 | 0.00 | 0.12 | 0.04 | 0.65 |
| Kharif-I 2018 | 0.00 | 0.39 | 0.05 | 0.35 |
| Kharif-II Baseline | 0.00 | 0.68 | 0.08 | 0.00 |
| Kharif-II 2017 | 0.00 | 0.58 | 0.23 | 0.00 |
| Kharif-II 2018 | 0.00 | 0.62 | 0.12 | 0.05 |

| **Polder 43/2A** | **Aquaculture** | **Other agriculture** | **Rice** | **Fallow** |
|---|---|---|---|---|
| Rabi Baseline | 0.00 | 0.51 | 0.06 | 0.07 |
| Rabi 2017 | 0.00 | 0.31 | 0.22 | 0.16 |
| Rabi 2018 | 0.00 | 0.18 | 0.12 | 0.36 |
| Kharif-I Baseline | 0.00 | 0.15 | 0.01 | 0.48 |
| Kharif-I 2017 | 0.00 | 0.15 | 0.04 | 0.50 |
| Kharif-I 2018 | 0.00 | 0.29 | 0.12 | 0.25 |
| Kharif-II Baseline | 0.00 | 0.57 | 0.06 | 0.00 |

| | | | | |
|---|---|---|---|---|
| Kharif-II 2017 | 0.00 | 0.44 | 0.25 | 0.00 |
| Kharif-II 2018 | 0.00 | 0.43 | 0.23 | 0.00 |

| **Polder 43/2B** | **Aquaculture** | **Other agriculture** | **Rice** | **Fallow** |
|---|---|---|---|---|
| Rabi Baseline | 0.00 | 0.38 | 0.04 | 0.33 |
| Rabi 2017 | 0.00 | 0.52 | 0.24 | 0.07 |
| Rabi 2018 | 0.00 | 0.36 | 0.14 | 0.31 |
| Kharif-I Baseline | 0.00 | 0.44 | 0.04 | 0.27 |
| Kharif-I 2017 | 0.00 | 0.09 | 0.03 | 0.70 |
| Kharif-I 2018 | 0.00 | 0.30 | 0.06 | 0.44 |
| Kharif-II Baseline | 0.00 | 0.68 | 0.07 | 0.00 |
| Kharif-II 2017 | 0.00 | 0.56 | 0.26 | 0.00 |
| Kharif-II 2018 | 0.00 | 0.62 | 0.18 | 0.01 |

| **Polder 43/2D** | **Aquaculture** | **Other agriculture** | **Rice** | **Fallow** |
|---|---|---|---|---|
| Rabi Baseline | 0.00 | 0.44 | 0.10 | 0.17 |
| Rabi 2017 | 0.00 | 0.38 | 0.32 | 0.09 |
| Rabi 2018 | 0.00 | 0.26 | 0.19 | 0.31 |
| Kharif-I Baseline | 0.00 | 0.31 | 0.06 | 0.34 |
| Kharif-I 2017 | 0.00 | 0.13 | 0.02 | 0.64 |
| Kharif-I 2018 | 0.00 | 0.24 | 0.08 | 0.43 |
| Kharif-II Baseline | 0.00 | 0.58 | 0.13 | 0.00 |
| Kharif-II 2017 | 0.00 | 0.46 | 0.33 | 0.00 |

| | | | | |
|---|---|---|---|---|
| Kharif-II 2018 | 0.00 | 0.50 | 0.26 | 0.00 |

| **Polder 43/2E** | **Aquaculture** | **Other agriculture** | **Rice** | **Fallow** |
|---|---|---|---|---|
| Rabi Baseline | 0.00 | 0.49 | 0.03 | 0.16 |
| Rabi 2017 | 0.00 | 0.50 | 0.25 | 0.04 |
| Rabi 2018 | 0.00 | 0.40 | 0.14 | 0.24 |
| Kharif-I Baseline | 0.00 | 0.28 | 0.01 | 0.39 |
| Kharif-I 2017 | 0.00 | 0.02 | 0.02 | 0.75 |
| Kharif-I 2018 | 0.00 | 0.21 | 0.04 | 0.53 |
| Kharif-II Baseline | 0.00 | 0.64 | 0.03 | 0.00 |
| Kharif-II 2017 | 0.00 | 0.52 | 0.27 | 0.00 |
| Kharif-II 2018 | 0.00 | 0.60 | 0.17 | 0.00 |

| **Polder 43/2F** | **Aquaculture** | **Other agriculture** | **Rice** | **Fallow** |
|---|---|---|---|---|
| Rabi Baseline | 0.00 | 0.49 | 0.04 | 0.15 |
| Rabi 2017 | 0.00 | 0.45 | 0.18 | 0.09 |
| Rabi 2018 | 0.00 | 0.22 | 0.05 | 0.42 |
| Kharif-I Baseline | 0.00 | 0.34 | 0.02 | 0.32 |
| Kharif-I 2017 | 0.00 | 0.16 | 0.05 | 0.51 |
| Kharif-I 2018 | 0.00 | 0.42 | 0.08 | 0.19 |
| Kharif-II Baseline | 0.00 | 0.63 | 0.04 | 0.00 |
| Kharif-II 2017 | 0.00 | 0.51 | 0.21 | 0.00 |
| Kharif-II 2018 | 0.00 | 0.57 | 0.12 | 0.00 |

| **Polder 47/3** | **Aquaculture** | **Other agriculture** | **Rice** | **Fallow** |
|---|---|---|---|---|
| Rabi Baseline | 0.00 | 0.23 | 0.02 | 0.61 |

| | | | | |
|---|---|---|---|---|
| Rabi 2017 | 0.00 | 0.24 | 0.10 | 0.55 |
| Rabi 2018 | 0.00 | 0.15 | 0.06 | 0.63 |
| Kharif-I Baseline | 0.00 | 0.12 | 0.03 | 0.72 |
| Kharif-I 2017 | 0.00 | 0.02 | 0.01 | 0.87 |
| Kharif-I 2018 | 0.00 | 0.14 | 0.04 | 0.66 |
| Kharif-II Baseline | 0.00 | 0.72 | 0.14 | 0.00 |
| Kharif-II 2017 | 0.00 | 0.39 | 0.51 | 0.00 |
| Kharif-II 2018 | 0.00 | 0.45 | 0.35 | 0.05 |

| **Polder 47/4** | **Aquaculture** | **Other agriculture** | **Rice** | **Fallow** |
|---|---|---|---|---|
| Rabi Baseline | 0.01 | 0.33 | 0.03 | 0.50 |
| Rabi 2017 | 0.01 | 0.28 | 0.15 | 0.44 |
| Rabi 2018 | 0.01 | 0.11 | 0.04 | 0.62 |
| Kharif-I Baseline | 0.01 | 0.21 | 0.03 | 0.62 |
| Kharif-I 2017 | 0.01 | 0.06 | 0.03 | 0.78 |
| Kharif-I 2018 | 0.01 | 0.28 | 0.12 | 0.37 |
| Kharif-II Baseline | 0.01 | 0.73 | 0.13 | 0.00 |
| Kharif-II 2017 | 0.01 | 0.40 | 0.48 | 0.00 |
| Kharif-II 2018 | 0.01 | 0.45 | 0.27 | 0.05 |

| **Polder 55/2A** | **Aquaculture** | **Other agriculture** | **Rice** | **Fallow** |
|---|---|---|---|---|
| Rabi Baseline | 0.00 | 0.36 | 0.13 | 0.24 |
| Rabi 2017 | 0.00 | 0.45 | 0.29 | 0.08 |
| Rabi 2018 | 0.00 | 0.33 | 0.24 | 0.21 |
| Kharif-I | 0.00 | 0.22 | 0.08 | 0.43 |

| | | | | |
|---|---|---|---|---|
| Baseline | | | | |
| Kharif-I 2017 | 0.00 | 0.05 | 0.03 | 0.73 |
| Kharif-I 2018 | 0.00 | 0.17 | 0.04 | 0.57 |
| Kharif-II Baseline | 0.00 | 0.53 | 0.20 | 0.00 |
| Kharif-II 2017 | 0.00 | 0.47 | 0.34 | 0.00 |
| Kharif-II 2018 | 0.00 | 0.50 | 0.29 | 0.00 |

| Polder 55/2C | Aquaculture | Other agriculture | Rice | Fallow |
|---|---|---|---|---|
| Rabi Baseline | 0.00 | 0.32 | 0.07 | 0.32 |
| Rabi 2017 | 0.00 | 0.45 | 0.23 | 0.10 |
| Rabi 2018 | 0.00 | 0.24 | 0.14 | 0.39 |
| Kharif-I Baseline | 0.00 | 0.34 | 0.06 | 0.31 |
| Kharif-I 2017 | 0.00 | 0.16 | 0.04 | 0.58 |
| Kharif-I 2018 | 0.00 | 0.32 | 0.08 | 0.37 |
| Kharif-II Baseline | 0.00 | 0.58 | 0.13 | 0.00 |
| Kharif-II 2017 | 0.00 | 0.51 | 0.27 | 0.00 |
| Kharif-II 2018 | 0.00 | 0.55 | 0.22 | 0.00 |

## Appendix C. Cropping intensity for all non-BGP polders

In the Table below all cropping intensity results for all non-BGP polders in the districts of Patuakhali, Khulna, Satkhira, and Barguna are given. The shapes of the non-BGP polders are taken from the ‘Other Polders BWDB’ shapefile, provided by BGP. For polders that partly fall in any of the four districts and partly outside, only the data that falls within the project area is taken into account; meaning that data of the polder outside Patuakhali, Khulna, Satkhira, and Barguna is not given here. Parts of polders and schemes/projects with a size under 10km2 are removed as the information is not deemed a representation of the entire polder.

Table C.1 Significance test (Cohen’s D test) for cropping intensity changes (with aquaculture) between

2017 and the baseline in non-BGP polders

| Polder | Area in km2 | Baseline Mean | 2017 mean | Change from baseline to 2017 (in absolute decimals) | Cohen's D | Effect Size |
|---|---|---|---|---|---|---|
| 1 | 281 | 1.2 | 1.5 | 0.2 | 0.4 | small |
| 10/12 | 168 | 0.9 | 1.3 | 0.4 | 0.9 | large |
| 13-14/1-2 | 155 | 0.8 | 1.2 | 0.4 | 0.9 | large |
| 14/1 | 23 | 0.8 | 1.0 | 0.3 | 0.6 | medium |
| 15 | 32 | 0.9 | 1.0 | 0.1 | 0.5 | small |
| 16 | 84 | 0.9 | 1.2 | 0.3 | 0.5 | medium |
| 17/1 | 50 | 0.9 | 1.3 | 0.4 | 0.9 | large |
| 17/2 | 30 | 1.1 | 1.5 | 0.4 | 0.7 | medium |
| 18/ 19 | 32 | 0.9 | 1.0 | 0.1 | 0.4 | small |
| 20 | 15 | 0.8 | 1.0 | 0.2 | 0.6 | medium |
| 21 | 10 | 0.9 | 1.1 | 0.2 | 0.7 | medium |
| 23 | 45 | 0.8 | 1.0 | 0.2 | 0.7 | medium |
| 25 | 21 | 0.9 | 1.0 | 0.1 | 0.3 | small |
| 3 | 182 | 0.7 | 1.2 | 0.5 | 1.0 | large |
| 31 (excluding 31/ Part) | 75 | 1.0 | 1.2 | 0.2 | 0.5 | small |
| 32 | 62 | 1.0 | 1.5 | 0.5 | 1.2 | large |
| 33 | 102 | 0.8 | 1.3 | 0.5 | 1.2 | large |
| 34/2 (excluding 34/2 Part) | 11 | 1.3 | 1.9 | 0.6 | 1.4 | large |
| 36/1 | 17 | 1.3 | 2.3 | 1.0 | 1.8 | large |
| 39/1A | 124 | 1.0 | 1.7 | 0.7 | 1.1 | large |
| 9/1D | 35 | 1.1 | 2.0 | 0.9 | 3.4 | large |
| 39/2 | 51 | 1.1 | 2.2 | 1.1 | 3.4 | large |

| | | | | | | |
|---|---|---|---|---|---|---|
| 39/2A | 40 | 1.2 | 2.2 | 1.0 | 2.6 | large |
| 4 | 103 | 0.9 | 1.0 | 0.1 | 0.3 | small |
| 40/1 | 20 | 1.1 | 1.8 | 0.7 | 2.0 | large |
| 40/2 | 45 | 1.0 | 2.0 | 1.0 | 3.4 | large |
| 41/1 | 42 | 1.2 | 2.2 | 0.9 | 2.8 | large |
| 41/2 | 39 | 1.3 | 2.4 | 1.1 | 2.8 | large |
| 41/3 | 11 | 1.3 | 2.2 | 0.9 | 2.8 | large |
| 41/4 | 18 | 1.1 | 2.1 | 1.0 | 3.3 | large |
| 41/5 | 38 | 1.1 | 2.1 | 1.0 | 3.1 | large |
| 41/6A | 73 | 1.2 | 2.2 | 0.9 | 2.9 | large |
| 41/6B | 39 | 1.2 | 2.1 | 0.9 | 3.8 | large |
| 41/7 | 63 | 1.3 | 2.1 | 0.9 | 2.4 | large |
| 41/7A | 61 | 1.5 | 2.2 | 0.7 | 1.8 | large |
| 41/7B | 57 | 1.3 | 2.2 | 0.9 | 2.5 | large |
| 42 | 28 | 1.0 | 2.0 | 1.0 | 2.9 | large |
| 43/1 | 146 | 1.0 | 1.7 | 0.7 | 1.4 | large |
| 43/1B | 26 | 1.3 | 2.1 | 0.8 | 2.5 | large |
| 43/2C | 30 | 1.0 | 1.8 | 0.8 | 2.3 | large |
| 44 | 193 | 1.0 | 1.7 | 0.7 | 1.7 | large |
| 45 | 40 | 1.0 | 1.8 | 0.8 | 2.1 | large |
| 46 | 48 | 1.0 | 1.8 | 0.8 | 2.4 | large |
| 47/1 | 21 | 1.0 | 1.6 | 0.6 | 1.5 | large |
| 47/2 | 10 | 1.0 | 1.6 | 0.7 | 1.5 | large |
| 47/5 | 25 | 1.1 | 2.0 | 0.9 | 1.9 | large |
| 48 | 51 | 1.0 | 1.4 | 0.5 | 0.8 | medium |
| 5 | 548 | 1.1 | 2.1 | 0.9 | 3.4 | large |
| 52/53A | 31 | 1.1 | 2.0 | 0.9 | 3.2 | large |

| | | | | | | |
|---|---|---|---|---|---|---|
| 52/53A &52/53B | 52 | 1.2 | 2.1 | 0.9 | 2.7 | large |
| 54 | 25 | 1.2 | 2.2 | 1.0 | 2.6 | large |
| 54/A&B | 76 | 1.3 | 2.2 | 0.9 | 2.3 | large |
| 55/1 | 101 | 1.5 | 2.1 | 0.6 | 2.1 | large |
| 55/2B | 31 | 1.3 | 2.1 | 0.8 | 2.3 | large |
| 55/2D | 152 | 1.4 | 2.0 | 0.6 | 2.0 | large |
| 55/2E | 126 | 1.2 | 2.1 | 0.9 | 2.4 | large |
| 55/3 | 102 | 1.0 | 1.8 | 0.8 | 2.1 | large |
| 55/4 | 51 | 1.2 | 1.4 | 0.3 | 0.5 | small |
| 6-8 | 336 | 0.9 | 1.1 | 0.2 | 0.5 | medium |
| 7/1 | 36 | 1.0 | 1.5 | 0.5 | 1.0 | large |
| 7/2 | 108 | 0.9 | 1.2 | 0.3 | 0.6 | medium |
| 9 | 11 | 1.2 | 2.1 | 0.9 | 1.3 | large |
| Barakpur Digulia Scheme | 40 | 1.5 | 2.3 | 0.8 | 1.6 | large |
| Barnal Salimpur Kolabashukhali System | 152 | 1.2 | 1.5 | 0.2 | 0.4 | small |
| Bhutiar Beel Drainage Scheme | 62 | 1.37 | 2.41 | 1.04 | 1.91 | large |
| Bibichini Projects | 31 | 1.53 | 2.15 | 0.62 | 1.79 | large |
| Itabaria Lebukhali Project | 31 | 1.47 | 2.13 | 0.65 | 2.06 | large |
| Kalaroa Drainage Improvement Project | 35 | 1.64 | 2.06 | 0.42 | 0.91 | large |
| Makla Beel Drainage Scheme | 43 | 1.64 | 2.16 | 0.52 | 1.19 | large |
| Nurania-Betagram Beel Drainage Scheme | 13 | 1.85 | 2.24 | 0.39 | 0.90 | large |
| Subidkhali-Madhabkhal Project | 46 | 1.41 | 1.98 | 0.57 | 0.93 | large |
| Tala and Other Beel | 62 | 1.06 | 1.99 | 0.93 | 2.25 | large |

| | | | | | | |
|---|---|---|---|---|---|---|
| Unknown (Khulna city) | 39 | 1.59 | 2.11 | 0.52 | 1.60 | large |

Table C.2 Significance test (Cohen's D test) for cropping intensity changes (with aquaculture) between 201 and the baseline in non-BGP polders

| Polder | Area in km2 | Baseline Mean | 2018 mean | Change from baseline to 2018 (in absolute decimals) | Cohen's D | Effect Size |
|---|---|---|---|---|---|---|
| 1 | 1.2 | 1.5 | 0.3 | 0.5 | small | 1.2 |
| 10/12 | 0.9 | 1.4 | 0.4 | 0.9 | large | 0.9 |
| 13-14/1-2 | 0.8 | 1.3 | 0.5 | 1.1 | large | 0.8 |
| 14/1 | 0.8 | 1.1 | 0.3 | 0.6 | medium | 0.8 |
| 15 | 0.9 | 1.0 | 0.1 | 0.4 | small | 0.9 |
| 16 | 0.9 | 1.2 | 0.3 | 0.5 | small | 0.9 |
| 17/1 | 0.9 | 1.4 | 0.5 | 1.0 | large | 0.9 |
| 17/2 | 1.1 | 1.6 | 0.5 | 0.7 | medium | 1.1 |
| 18/ 19 | 0.9 | 1.0 | 0.1 | 0.4 | small | 0.9 |
| 20 | 0.8 | 1.0 | 0.2 | 0.7 | medium | 0.8 |
| 21 | 0.9 | 1.1 | 0.2 | 0.8 | medium | 0.9 |
| 23 | 0.8 | 1.0 | 0.2 | 0.7 | medium | 0.8 |
| 25 | 0.9 | 1.0 | 0.1 | 0.4 | small | 0.9 |
| 3 | 0.7 | 1.3 | 0.6 | 1.1 | large | 0.7 |
| 31 (excluding 31/ Part) | 1.0 | 1.2 | 0.2 | 0.4 | small | 1.0 |
| 32 | 1.0 | 1.6 | 0.6 | 1.4 | large | 1.0 |
| 33 | 0.8 | 1.3 | 0.5 | 1.2 | large | 0.8 |
| 34/2 (excluding 34/2 Part) | 1.3 | 2.0 | 0.6 | 1.8 | large | 1.3 |
| 36/1 | 1.3 | 2.1 | 0.8 | 1.7 | large | 1.3 |
| 39/1A | 1.0 | 1.8 | 0.8 | 1.5 | large | 1.0 |
| 9/1D | 1.1 | 2.0 | 0.8 | 2.8 | large | 1.1 |
| 39/2 | 1.1 | 2.2 | 1.2 | 3.3 | large | 1.1 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 39/2A | 1.2 | 2.2 | 1.0 | 2.8 | large | 1.2 |
| 4 | 0.9 | 1.0 | 0.1 | 0.3 | small | 0.9 |
| 40/1 | 1.1 | 1.8 | 0.7 | 1.9 | large | 1.1 |
| 40/2 | 1.0 | 1.9 | 0.8 | 2.6 | large | 1.0 |
| 41/1 | 1.2 | 2.1 | 0.9 | 2.7 | large | 1.2 |
| 41/2 | 1.3 | 2.0 | 0.7 | 1.9 | large | 1.3 |
| 41/3 | 1.3 | 2.1 | 0.9 | 2.2 | large | 1.3 |
| 41/4 | 1.1 | 2.0 | 0.9 | 2.3 | large | 1.1 |
| 41/5 | 1.1 | 1.8 | 0.7 | 1.8 | large | 1.1 |
| 41/6A | 1.2 | 2.1 | 0.9 | 2.7 | large | 1.2 |
| 41/6B | 1.2 | 2.0 | 0.8 | 3.2 | large | 1.2 |
| 41/7 | 1.3 | 2.1 | 0.8 | 2.7 | large | 1.3 |
| 41/7A | 1.5 | 2.0 | 0.5 | 1.9 | large | 1.5 |
| 41/7B | 1.3 | 2.1 | 0.8 | 2.7 | large | 1.3 |
| 42 | 1.0 | 2.0 | 0.9 | 2.6 | large | 1.0 |
| 43/1 | 1.0 | 1.5 | 0.5 | 0.9 | large | 1.0 |
| 43/1B | 1.3 | 2.2 | 0.8 | 2.4 | large | 1.3 |
| 43/2C | 1.0 | 1.8 | 0.8 | 1.9 | large | 1.0 |
| 44 | 1.0 | 1.6 | 0.6 | 1.3 | large | 1.0 |
| 45 | 1.0 | 1.7 | 0.7 | 1.5 | large | 1.0 |
| 46 | 1.0 | 1.6 | 0.6 | 1.2 | large | 1.0 |
| 47/1 | 1.0 | 1.5 | 0.5 | 1.2 | large | 1.0 |
| 47/2 | 1.0 | 1.4 | 0.4 | 0.7 | medium | 1.0 |
| 47/5 | 1.1 | 1.9 | 0.8 | 1.6 | large | 1.1 |
| 48 | 1.0 | 1.3 | 0.3 | 0.6 | medium | 1.0 |
| 5 | 1.1 | 2.1 | 0.9 | 3.8 | large | 1.1 |
| 52/53A | 1.1 | 2.1 | 0.9 | 3.1 | large | 1.1 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 52/53A &52/53B | 1.2 | 2.2 | 1.0 | 2.6 | large | 1.2 |
| 54 | 1.2 | 2.1 | 0.9 | 2.1 | large | 1.2 |
| 54/A&B | 1.3 | 2.1 | 0.8 | 2.3 | large | 1.3 |
| 55/1 | 1.5 | 2.0 | 0.5 | 2.3 | large | 1.5 |
| 55/2B | 1.3 | 2.0 | 0.7 | 2.9 | large | 1.3 |
| 55/2D | 1.4 | 2.0 | 0.6 | 2.6 | large | 1.4 |
| 55/2E | 1.2 | 2.0 | 0.8 | 2.7 | large | 1.2 |
| 55/3 | 1.0 | 2.0 | 0.9 | 3.0 | large | 1.0 |
| 55/4 | 1.2 | 1.5 | 0.3 | 0.5 | medium | 1.2 |
| 6-8 | 0.9 | 1.1 | 0.2 | 0.5 | small | 0.9 |
| 7/1 | 1.0 | 1.5 | 0.5 | 1.0 | large | 1.0 |
| 7/2 | 0.9 | 1.2 | 0.3 | 0.6 | medium | 0.9 |
| 9 | 1.2 | 1.8 | 0.7 | 1.2 | large | 1.2 |
| Barakpur Digulia Scheme | 1.5 | 2.1 | 0.6 | 1.4 | large | 1.5 |
| Barnal Salimpur Kolabashukhali System | 1.2 | 1.5 | 0.3 | 0.5 | small | 1.2 |
| Bhutiar Beel Drainage Scheme | 1.4 | 2.2 | 0.8 | 1.7 | large | 1.4 |
| Bibichini Projects | 1.5 | 2.1 | 0.5 | 1.8 | large | 1.5 |
| Itabaria Lebukhali Project | 1.5 | 2.0 | 0.6 | 2.2 | large | 1.5 |
| Kalaroa Drainage Improvement Project | 1.6 | 2.1 | 0.5 | 1.1 | large | 1.6 |
| Makla Beel Drainage Scheme | 1.6 | 2.3 | 0.7 | 1.5 | large | 1.6 |
| Nurania-Betagram Beel Drainage Scheme | 1.9 | 2.5 | 0.6 | 1.3 | large | 1.9 |
| Subidkhali-Madhabkhal Project | 1.4 | 2.2 | 0.8 | 1.4 | large | 1.4 |
| Tala and Other Beel | 1.1 | 2.1 | 1.1 | 1.9 | large | 1.1 |

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|---|---|---|---|---|---|---|
| Unknown (Khulna city) | 1.6 | 2.1 | 0.5 | 1.6 | large | 1.6 |