Supplementary Document:

Contrasting development trajectories for coastal Bangladesh to the end of century
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FVCOM river salinity results used as ‘true’ to train emulators (ppt, Q0 BaU scenario, year 2000)

ΔDIEM emulated river salinity Union level (ppt, Q0 BaU scenario, year 2000) (Payo et al., 2017)

Figure 5. Linear emulators of mean water level in the river: (b) large emulated mean river elevation are well within the uncertainty band of factor 10 of simulated values. (Payo et al., 2017)

Figure 31.A1: Accuracy of groundwater salinity emulator in ΔDIEM at ~100m depth (right panels). (x: simulated value;  : emulated value) (Lázár et al., 2018)

Annual median soil salinity (dS/m) - 2009
Observations: Dasgupta et al. (2015)

Annual maximum soil salinity (dS/m) – 2009
Observations: Dasgupta et al. (2015)
The proposed soil salinity model can reproduce the observed daily variability reported by Mondal et al. [2001] for sesame farming during the period 1996–1998 if salt flux from flooding is considered. (Payo et al., 2017)

**Figure S12**: Selected ΔDIEM model performance comparisons (bio-physical)

Validation of the process-based household component of ΔDIEM (Lázár et al., 2018)

Black lines show the simulated mean study area values, shaded area shows the min-max simulated range within the study area, and grey dots and diamonds are observations. Observations: a) BBS (2011) Table 4.4; b) BBS (2011) Table 5.3; c) BBS (2011) Table 5.4; d) dots: rural inequality: Ferdousti and Dehai (2014), Diamonds: national inequality - UNDP (http://hdr.undp.org/en/content/income-gini-coefficient accessed on 08/07/2016); e) World Bank: People living on less than $1.90 a day (http://povertydata.worldbank.org/poverty/country/BD accessed on 08/07/2016)

**Figure S13**: Selected ΔDIEM model performance comparisons (socio-economic)
Table S1: Household archetypes based on the seasonally dominant livelihood and land size (based on the ESPA Deltas’ household survey)

| Archetype ID | Seasonally dominant livelihood (Season 1 – Season 2 – Season 3) (February-June; June-October; October-February) | Cumulative occurrence (%) | No. of households |
|--------------|-------------------------------------------------------------------------------------------------------------|---------------------------|-------------------|
| 1            | SmallBusiness – SmallBusiness – SmallBusiness                                                              | 19                        | 103               |
| 2            | CottageIndustry – CottageIndustry – CottageIndustry                                                        | 33                        | 132               |
| 3            | FarmOwner – FarmOwner – FarmOwner                                                                         | 38                        | 9                 |
| 4            | Fisher – Fisher – Fisher                                                                                    | 42                        | 42                |
| 5            | CottageIndustry – FarmLabour – CottageIndustry                                                               | 45                        | 32                |
| 6            | CottageIndustry – SmallBusiness – SmallBusiness                                                             | 47                        | 17                |
| 7            | SmallBusiness – SmallBusiness – CottageIndustry                                                              | 49                        | 15                |
| 8            | SmallBusiness – SmallBusiness – FarmOwner                                                                  | 52                        | 0                 |
| 9            | FarmOwner – CottageIndustry – CottageIndustry                                                                | 53                        | 9                 |
| 10           | FarmOwner – noJob – FarmOwner                                                                               | 55                        | 0                 |
| 11           | CottageIndustry – SmallBusiness – CottageIndustry                                                            | 56                        | 13                |
| 12           | FarmOwner – SmallBusiness – FarmOwner                                                                       | 58                        | 0                 |
| 13           | CottageIndustry – Fisher – CottageIndustry                                                                   | 59                        | 14                |
| 14           | FarmOwner – SmallBusiness – SmallBusiness                                                                   | 61                        | 0                 |
| 15           | SmallBusiness – CottageIndustry – SmallBusiness                                                              | 62                        | 11                |
| 16           | CottageIndustry – CottageIndustry – SmallBusiness                                                             | 64                        | 8                 |
| 17           | FarmLabour – CottageIndustry – CottageIndustry                                                                | 65                        | 20                |
| 18           | FarmLabour – FarmLabour – CottageIndustry                                                                    | 66                        | 20                |
| 19           | SmallBusiness – CottageIndustry – CottageIndustry                                                             | 68                        | 8                 |
| 20           | Forest Good Collector                                                                                        | 68                        | 11                |
**Table S2: Development trajectory assumptions**

| Policy strategy | Description | Embankments | Infrastructure repair time | Migration |
|-----------------|-------------|-------------|---------------------------|-----------|
| 1. ‘Protect’    | This scenario assumes large investments in enhanced flood embankments and drainage systems to adapt to the growing risks of SLR like occurs in the Netherlands. Water pumping ensures that waterlogging never happens. | +3m above current height throughout the simulation | short, only 6 months after dike failure | autonomous relocation (see assumptions in text) |
| 2. ‘Unmanaged retreat’ | This scenario explores the implications of practically no investment in protection or adaptation to SLR in the coastal zone. It provides a baseline assessment of the potential impacts of climate change in the absence of governance. | embankments progressively deteriorate at a rate of -5cm/year (-4m by 2100) | long, 60 months after dike failure | autonomous relocation |
| 3. ‘Reactive relocation’ | This scenario envisages some government action to cope with the growing pressures of climate and environmental change, with an emphasis upon relocation of coastal communities. Abandonment in reality is rare and motivated to prevent the loss of life and exposure to hazard, or loss of livelihood (Hino et al., 2017, Jha, 2010). | maintained at current level until relocation occurs | 18 months, unless the polder is abandoned (i.e. all people are moved away) | relocation of entire communities after 50% of population have moved away based on individual migration decisions |
| 4. ‘Build elevation’ | This scenario envisages working with natural processes to naturally deposit sediment through controlled flooding termed as Tidal River Management (TRM) in Bangladesh (Gain et al., 2017, Mutahara et al., 2017, van Staveren et al., 2016). TRM is only exercised in selected locations at present. | maintained at current level | 18 months, similar to what happened after the SIDR cyclone in Polder 32 | autonomous relocation |

Here, the maximum benefit of TRM is explored by implementing it in all polders simultaneously (Darby et al., 2018). TRM starts in 2020, lasts for 5 years, covers 20% of the polder area and operates when river salinity is ≤10 ppt. Assumed daily sedimentation rate (when inundation occurs) is 0.42 cm/day and 0.21 cm/day for the cut- and furthest points of the TRM area, respectively (calculated from Amir et al., 2013). Sedimentation updates the union hypsometric curves (elevation-cumulative area curves), the drainage rates and flooding area/depth in ΔDIEM. Compensation for farm-based households: 1000 BDT/year·ha⁻¹ (~$12 USD/year·ha⁻¹) during TRM years.
| Land cover classes | Less sustainable                                                                 | More Sustainable                                                                 |
|--------------------|----------------------------------------------------------------------------------|----------------------------------------------------------------------------------|
| **Agriculture**    | - Agriculture land is abandoned (by 20% in the highly saline areas and by 10% in the moderately saline areas) due to high salinity levels.  
- Rice is the dominant crop (few other crops: as in 1990)  
- Very few new crops compared to present (i.e. no better yielding and higher salt tolerance varieties – present crops). | - Slightly smaller agriculture area (-5%) that was given up to protect certain areas (mangrove and non-mangrove land cover).  
- Rice still dominant, but more cash-crops (e.g. vegetables) and high yielding varieties  
- Use of deep groundwater irrigation and drinking water wells to minimise salinity impact  
- Targeted subsidy programs to promote land use zoning (30% increase in area if agriculture is promoted)  
- Several new crops with higher yield and higher salt tolerance. |
| **Aquaculture**    | - Saltwater shrimp area increases from Sundarbans clearings.  
- Freshwater prawn production is negligible. The land is either abandoned or rice is produced instead of aquaculture. | - Saltwater shrimp area same, but more sustainable management  
- Targeted subsidy programs to promote land use zoning (30% increase in area if aquaculture is promoted) |
| **Mangrove**       | - Decreased area everywhere (-10%) for more agriculture land and aquaculture areas.  
- Significant encroachment in Sundarbans (-20%) to turn land to shrimp production areas. | - Increased mangrove area especially along the coast (converted from agriculture).  
- Targeted subsidy programs to promote land use zoning (20% increase in area if tourism is promoted) |
| **Non-mangrove vegetation** | - Decreased area everywhere (-10%) for more agriculture land and aquaculture areas. | - Slightly increased area (converted from agriculture). |
| **Rural settlement** | - No change | - Less settlements on floodplains (less damage, but no overall change in % settlement area within the unions)  
- Targeted subsidy programs to promote land use zoning (10% increase in area if tourism is promoted) |
| **Urban settlement** | - No change | - Less settlements on floodplains (less damage, but no overall change in % settlement area within the unions)  
- Targeted subsidy programs to promote land use zoning (30% increase in area if urbanisation is promoted) |
| **Wetland/Mudflat/Sand/Bare land** | - increase from abandoned agriculture land | - No change |
| **Water Surface Area** | - No change | - No change |
Table S4: Mean decadal total rice produce (tons)

| Low sea level rice | low development | high development |
|--------------------|----------------|-----------------|
|                    | 2020s | 2040s | 2090s | 2020s | 2040s | 2090s |
| 1.Protect          | 1,397,712 | 1,262,277 | 1,103,327 | 3,696,565 | 3,456,877 | 9,582,366 |
| 2.unmanagedRetreat | 1,350,640 | 1,223,197 | 601,630 | 3,740,254 | 3,563,375 | 9,785,443 |
| 3.ReactiveRelocation | 1,339,000 | 1,195,062 | 876,408 | 3,710,778 | 3,537,338 | 9,783,060 |
| 4.BuildElevation   | 1,384,823 | 1,295,246 | 1,037,468 | 3,803,982 | 3,654,071 | 10,133,576 |
| Baseline           | 1,346,975 | 1,222,640 | 902,558 | 3,728,650 | 3,558,994 | 10,000,587 |

| High sea level | 2020s | 2040s | 2090s |
|----------------|-------|-------|-------|
| 1.Protect      | 1,336,496 | 1,177,270 | 1,008,969 |
| 2.unmanagedRetreat | 1,248,897 | 892,847 | 312,743 |
| 3.ReactiveRelocation | 1,245,193 | 980,439 | 532,894 |
| 4.BuildElevation | 1,332,701 | 1,178,695 | 753,205 |
| Baseline       | 1,274,063 | 1,060,481 | 578,421 |

Table S5: Cost of Tidal River Management in Bangladesh

| Source                  | Location       | cost (million BDT) | area (ha) | million BDT/ha |
|-------------------------|----------------|--------------------|-----------|----------------|
| Gain et al. (2017)      | Beel Pakhimara | 2620               | 700       | 3.74           |
|                         | Beel Khukshia  | 33.4               | 1170      | 0.03           |
| Amir et al. (2013)      | East Beel Khuksia | 285.85 | 900       | 0.32           |
|                         | East Beel Khuksia | 213.46 | 900       | 0.24           |
|                         | East Beel Khuksia | 355.84 | 900       | 0.40           |
|                         | Beel Kapalia    | 207.99             | 625       | 0.33           |
|                         | Beel Kapalia    | 161.67             | 625       | 0.26           |
|                         | Beel Kapalia    | 252.17             | 625       | 0.40           |

Mean: 0.71
Table S6: Evaluation of development trajectories

| Trajectory                  | Direct capital & maintenance cost (billion BDT) |
|-----------------------------|-----------------------------------------------|
| 1. Protect                  | 1080-2080*                                    |
| 2. Unmanaged retreat        | 0                                             |
| 3. Reactive relocation      | 458-1194**                                   |
| 4. Build elevation          | 219***                                        |

Notes:

* Cost = dike improvement + dike maintenance. There are 5000 km dikes in the study area, +3m increase in embankment height, dike raising cost: 0.7-1.2 million EUR/km/m (Table 2 for Vietnam, Jonkman et al., 2013). Dike maintenance: 0.02 million EUR/km/year (1 EUR = 100 BDT, 80 years => 80 billion BDT by 2100) (Table 2 for Vietnam, Jonkman et al., 2013).

** Cost = relocation + dike maintenance. The relocated people are between 0.44 and 1.66 million based on the simulations. Hino et al. (2017) estimates relocation cost for Fiji and UK Coastal Change Pathfinder as US$10,000 per person. 1 US$ = 85 BDT (17 October 2018 exchange rate). Dike maintenance: 0.02 million EUR/km/year (1 EUR = 100 BDT, 80 years => 80 billion BDT by 2100) (Table 2 for Vietnam, Jonkman et al., 2013).

*** Cost = TRM + dike maintenance + compensation. Total poldered areas of the study area (ha) is 976,496 ha. Only 20% is for impacted by TRM that is 195,299ha. Average cost of TRM is 0.71 million BDT/ha (see Table S2). Dike maintenance: 0.02 million EUR/km/year (1 EUR = 100 BDT, 80 years => 80 billion BDT by 2100) (Table 2 for Vietnam, Jonkman et al., 2013). The total agriculture land in the poldered areas is 559 thousand hectare, of which 111 thousand hectare (20 percent) is used during the TRM. By considering the 1000 BDT/ha/year compensation, this would cost the government 111,000 ha * 1000 BDT/ha * 5 years = 555 million BDT.

Table S7: Comparison of key bio-physical outputs with literature values

| Output variable          | Simulated result                                                                 | Literature values                                                                 |
|--------------------------|----------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|
| Total inundation area    | 500 to 3000 km² (monsoon flooding); <6000 km² (cyclone flooding)                 | for the entire coastal zone of Bangladesh (ca. 30% larger area):                   |
|                          |                                                                                  | • 5510 km² (Mohal and Hossain, 2007)                                              |
|                          |                                                                                  | • 4107 km² (WARPO, 2005)                                                          |
|                          |                                                                                  | for Khulna and Barisal districts only                                             |
|                          |                                                                                  | • 4356 km² (monsoon flooding, CCC, 2009b)                                         |
|                          |                                                                                  | • ca. 12,000 km² (cyclone flooding, CCC, 2009a)                                   |
| Soil salinity (km²)      | 8700 km² (year 2020)                                                            | • 8317.7 km² (calculated for our study area, year 2009, SRDI, 2012)              |
| Dry season soil salinity | 7-21%                                                                            | • 39.2% by 2050 (Dasgupta et al., 2015)                                           |
|                          | (%) change                                                                       | • 39% (+3277 km²) by 2100 (Mohal and Hossain, 2007)                               |
| Rice produce             | 3.6 million tons (year 2020, modern crop varieties)                               | • 3.56 million tons (Aus, Aman, Boro) for our study area (BBS, 2012).             |
Table S8: Sensitivities of different outputs to different drivers

In a local sensitivity analysis, the mean decadal simulated values (2089-2098) were compared with a baseline value (2015-24) for 36 plausible scenarios. The maximum range of the sensitivities was calculated for each driver and then normalised.

| Mean of simulations | inundation (km²) | soil salinity (dS/m) | Rice (tons) | GINI (%) | Poverty (%) | GDP/capita (BDT/month) |
|---------------------|------------------|----------------------|------------|----------|------------|------------------------|
| climate             | high             | very high            | low        | low      | low        | low                    |
| relative SLR        | high             | low                  | low        | low      | low        | low                    |
| cyclone intensity   | high             | moderate             | low        | low      | low        | low                    |
| polder maintenance  | very high        | low                  | low        | low      | low        | low                    |
| population size     | low              | low                  | low        | moderate | low        | very high              |
| micro economy       | low              | low                  | low        | moderate | very high  | high                   |
| land cover          | low              | low                  | low        | low      | low        | low                    |
| farming practices   | low              | very high            | very high  | very high| low        | moderate               |

Note: Sensitivity classes: low (0-24%), moderate (25-49%), high (50-74%), very high (75-100%)
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