3 Polder 15

3.1 Present situation and problems

Polder 15 has a relatively high population density (10 persons/ha), is located remotely (51 km from Satkhira) and in a high salinity area. Land use in the polder consists mostly of shrimp culture (Ghers). It was observed during the field visit (on 8 June 2020) that the 5 existing sluices are not fully functional for proper drainage and have deteriorated due to long use and saline water. Local people are constructing cross dams to store the water which creates water logging problem in the polder (CEIP-I, 2021). Manually operated tube-wells have been installed through horizontal boring pipe on embankment by the Gher owners for lifting water from the river to fulfil their demand of water inside the polder (CEIP-I, 2012).

Bank erosion from the Kobadak river is a main problem for the embankments. Many segments of the embankment have been damaged by wave action and eroded due to river flow. The CEIP-I Feasibility Study Report (CEIP-I, 2012) advised to protect about 15 km of embankments by afforestation on the foreshore area and several sections to be strengthened by bank and slope protection works. Note that Polder 15 is one of the CEIP-1 polders for which currently a feasibility design is ongoing.

Polder 15 also has a high cyclone risk. During cyclone AILA the embankment was overtopped, causing the polder area to be submerged by 1 to 1.5 m of surge water. About 75 people died, damage occurred & breaches formed at several places on the embankment. The polder area has remained under saline water due to damaged embankment since AILA (CEIP-I, 2012). In 2020, Polder 15 was affected severely by cyclone AMPHAN. A breach on the embankment had occurred and caused severe flooding.

Land use is dominated by shrimp production, as in many polders in the southwest region. Around 15% of the land is settlement, 10% for crops (mostly Aman rice) and the rest (75%) is aquaculture. The main cultivated species in this region is marine tiger shrimp (*Penaeus monodon*), locally called *bagda*. Apart from *P. monodon* also the giant fresh water shrimp (*Macrobrachium rosenbergii*), locally called *golda*, is a prominent species , but it is practiced more in the south central region (Bagerhat, Patuakhali). Shrimp *(P. monodon*) farming in the south eastern area rotates with salt production and some rice farming though in the more saline areas only shrimp are farmed (Azad et al., 2008). The cultivation of the shrimp has not come without environmental and social problems. Traditional rice farmers complained that the aquaculture owners modified the water system to their benefit and caused salinity in the polders to rise which resulted in damages to crops due to increased salinity of the water.

Table 3-1 Basic data of Polder 15

gross area (ha)	average elevation (m)	perimeter (km)	pop (2011)	pop density (#/ha)	erosion (km)	distance to main town (km)	salinity current	salinity future	shelter capacity
3,441	1.0	27	34,766	10.1	22	51	25.2	26.6	2,975

Parameter	**description**
Embankment	Main rivers Kobadak and Kholpetua: storm surge plus waves, river erosion
Embankment efficiency	**moderate**: >1,287 people per km
Salinity	**very high**: > 25 ppt
Waterlogging	Although whole polder has waterlogging (see Figure 3-5)), this may cause no problem because most of the polder is under shrimp culture.
Subsidence	land subsidence for West Ganges Region is relatively **low** (~2.5mm/y)
Distance to district capital	51 km to Satkhira **Remote polder**
Outside water level	Tides, surges, monsoon water levels: Determines embankment heights and drainage potential
Cropping intensity	
Cyclone risk	**high** economic risk; **Low** mortality risk

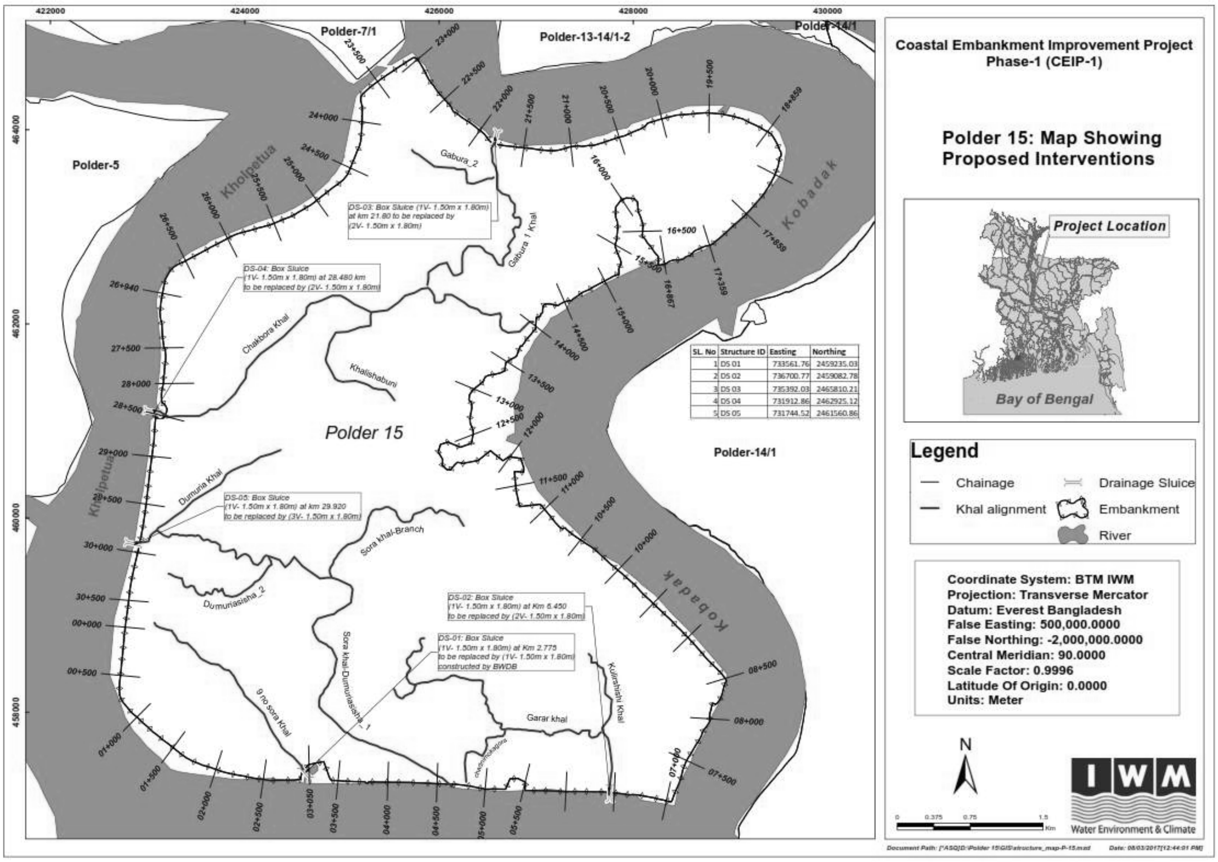

Figure 3-1 Map of Polder 15

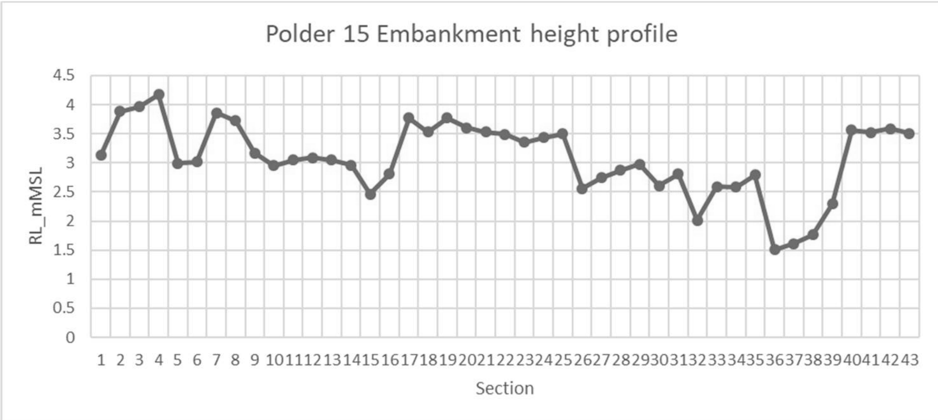

Figure 3-2 Current embankment profile

The general socioeconomic situation in the polder is as follows: the great majority of the population is engaged in the fisheries sector, in one way or another. Labourers work in the shrimp farms, whereas women and children from poor families are engaged in shrimp fry collection. During the winter season, people suffer from unemployment in the area and many migrate to other areas of the country to work in brick making and construction work. Other economic activities in the polder besides shrimp farming are small businesses, rice cultivation and fishing.

The majority of the population is poor, and mostly lives in katcha houses. The people build houses with an increased plinth height to avoid water entering their homes. Because the residence areas of the villages are congested, many houses are built at the river side of the embankment, which make them very vulnerable during disaster.

Figure 3-3 Land use in Polder 15 (ghers and Aman rice field)

Figure 3-4 Housing conditions in Polder 15

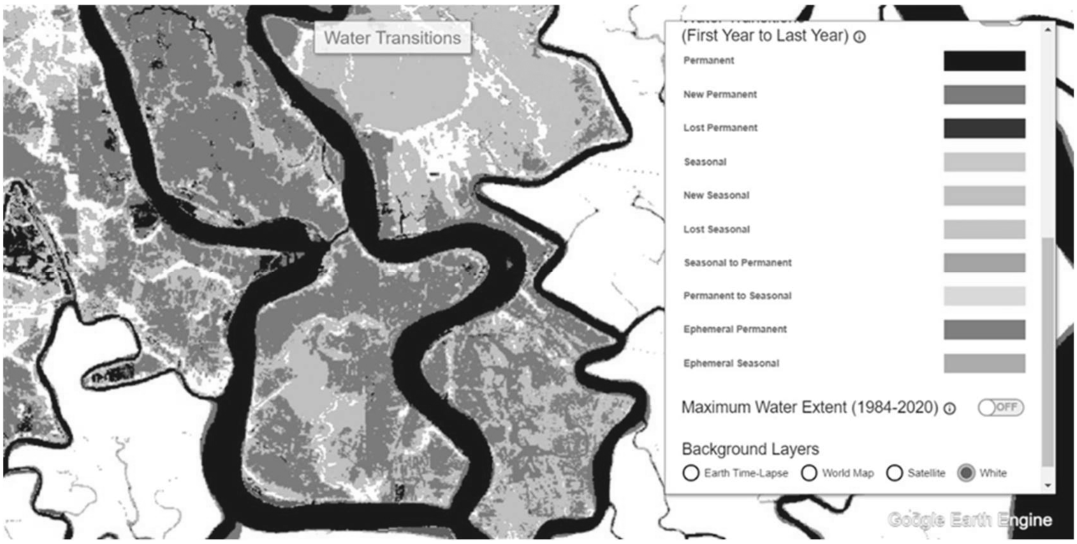

Figure 3-5 Flooding and drying map for polder 15 over the period 1984 – 2020, retrieved from http://global-surface-water.appspot.com/map. ‘New permanent’ refers to areas that were dry before 1984 but became permanent water bodies.

3.2 Future changes in boundary conditions

Precipitation: an increase rainfall is expected after 2070 during the monsoon (in the order of 4 to 9% relative to the year 2020). A decrease in rainfall during the winter months is projected after 2100 (in the order of -11%). Annual maximum daily precipitation is likely to increase after 2070 with 8 to 18%.

Subsidence: around 7 - 10 cm in 2050.

Cyclone frequency and intensity: both frequency and intensity are projected to increase significantly.

Salinity: is expected to increase somewhat. But is already quite high. Situation could change significantly if the Ganges Barrage is constructed and predominant farming system of shrimp culture is reduced or abandoned.

3.3 Polder design options and measures

3.3.1 Embankments

There is a need to restructure/improve the existing embankments. As the current embankment profile shows (Figure 3-2), it has not a uniform height and at its lowest point is only 1.5 m above mean sea level. The many tubes (20 inches) which are dug into the embankment for letting water in an out of the ghers weaken the embankment. It is mentioned that there are more than 500 of these pipe sets on the embankment throughout the polder.

Erosion control: bank (400m) and slope (4.44 km) protection works are advised for several sections of the embankments. (CEIP-I, 2012)

Afforestation: At several locations there is significant space between the toe of the embankment and the riverbank (up to 70-80m), at which locations mangroves could develop. Some 20 ha of foreshore afforestation has been identified (CEIP-I, 2012).

Table 3-2 presents a summary of embankment improvements.

Table 3-2 Proposed embankment improvements Polder 15

Embankment improvements	length
re-sectioning (upgrade to design crest level of 4.5m PWD)	23.92 km
Construction of retired embankment	6.86 km
Bank protection works	400 m
Slope protection works	4.44 km
Afforestation	20 ha
Land acquisition	21.95 ha

Source: CEIP-1 Feasibility Study (2012)

The embankments for polder 15 are classified as “Intermediate” type of embankments, while combined storm surge levels and waves result required embankments “Type 3A” (Figure 3-6) and “Type 3B” (Figure 3-7), depending on the characteristics of the embankments and its surroundings (details on the embankments design and costing can be found in Annex B). At locations of possible wave attack and locations that suffer from scour from river flow it is advised to include a stone or Concrete Cement blocks (CC) embankment that will protect the embankment from erosion. Depending on storm surge, average polder elevation and presence and magnitude of the wave attack the dimensions of the embankment and construction costs are determined (details can be found in Annex B).

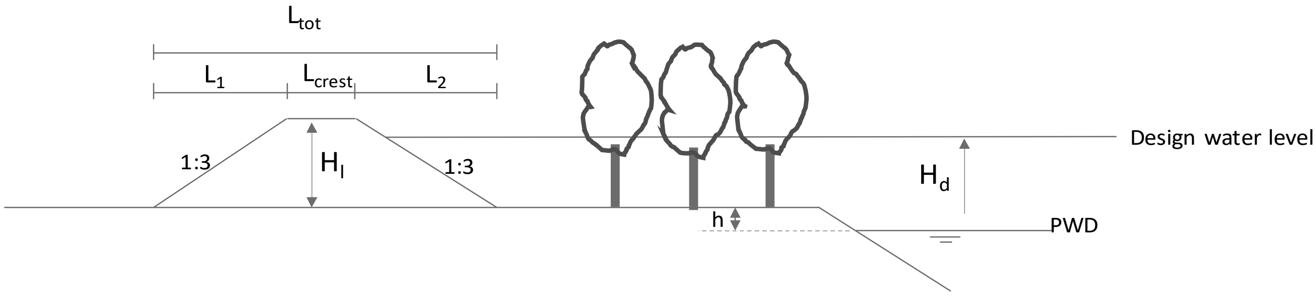

Figure 3-6; Embankment “Type 3A”

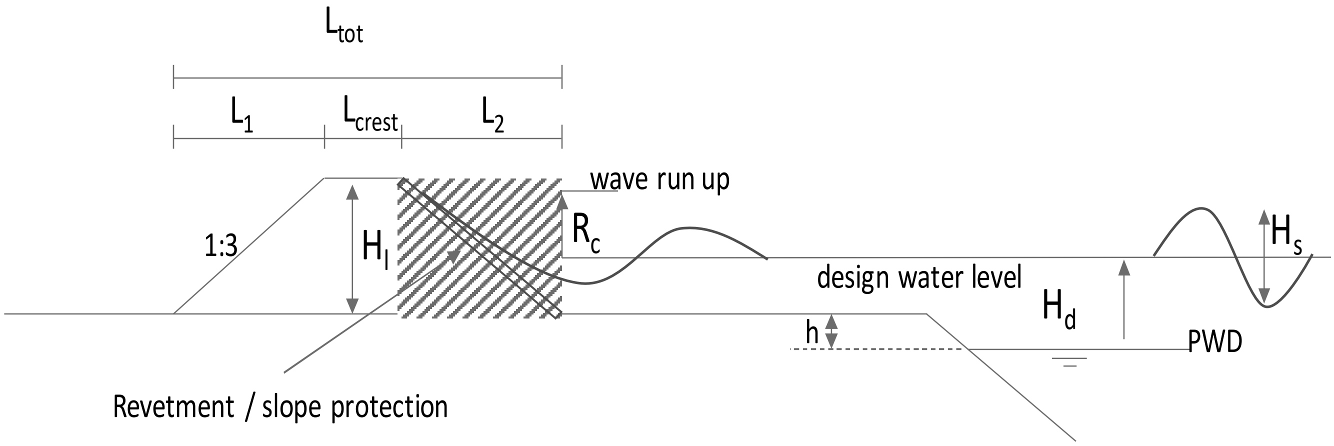

Figure 3-7; Embankment “Type 3B”

3.3.2 Sediment management

Tidal River Management (TRM) to restore sediment deposition in the polder is not needed when aquaculture will remain the main land use, hence waterlogging is not a serious problem.

3.3.3 Water management

The intensive shrimp culture activities cause high salinity in the polder surface and groundwater and is seriously limiting the agricultural potential. If in future the freshwater flow from the Ganges would improve, a more diverse land use could be envisaged. Besides shrimp production as a monoculture, for instance a combination of rice and shrimp could be feasible. The bottom of ghers act as a nutrient sink and these nutrients can be utilized by the rice plants. Also, a polyculture with mullet and mud crab could be practiced in brackish and saline water environments. In any case, the water management in Polder 15 is not so much about drainage, but more on providing the optimal mix of fresh and salt water to diversify aquaculture production.

Drainage conditions:

Currently there are 5 regulators with a total opening of 14.7 m^2. Average regulator opening is 2.94 m^2. However only one regulator seems operational (Table 3-3). The current drainage window is approx. 17 h per 24h. With 7.5 cm subsidence and 20.8 cm SLR in 2050 the drainage window will be reduced to 15.5 h (Figure 3-9).

Table 3-3 Regulator data for Polder 15

SL no.	Structure ID	Structure Type	No. of vent	Vent information				Condition
				Barrel length	Height (m)	Width (m)	m^2	
1	DS_01	Box	1	4.9	2	1.5	3	Good
2	DS_02	Box	1	3.6	2	1.5	3	Bad
3	DS_03	Box	1	3.6	2	1.5	3	Bad
4	DS_04	Box	1	3.6	1.8	1.5	2.7	Bad
5	DS_05	Box	1	3.6	2	1.5	3	Bad

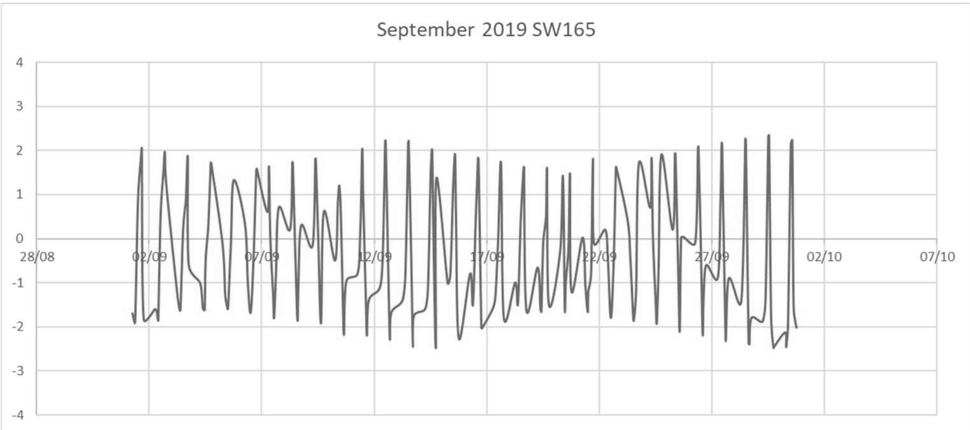

Figure 3-8 Water levels for station SW165 during the month of September 2019

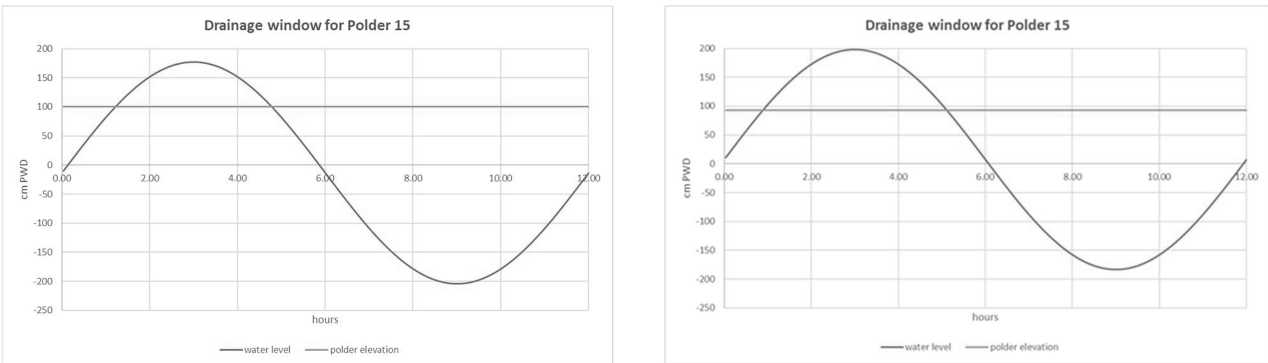

Figure 3-9 Drainage window (left: current, right: future) for Polder 15, based on average monsoon water level station SW165

The water balance model results (see Annex A) show that in wet and extremely wet years the existing drainage system is not able to keep the polder dry. But also during average years, there are 15 days with more than 20 cm of water on the fields. In wet years this increases in the future to 113 days and this accumulates to water levels of 1 m and more. This condition can be explained by the fact that the calculation assumes only one active regulator.

Also, the detailed drainage modelling exercise (IWM, 2022) reveals that polder 15 is vulnerable to water logging problem even in a 1 in 10-year return period design rainfall event without climate change. For more extreme conditions (1 in 25 and 1 in 50 year rainfall conditions) more than 80% of the polder is inundated with more than 30 cm of water.

From the survey conducted in 2021 it was observed that 4 out of the 5 existing regulators are in bad condition (see Table 3-3).. Should all 5 regulators work effectively (not shown in the graphs), the waterlogging conditions would be reduced significantly. For instance, under average rainfall conditions, water would be on the fields for only 2 days instead of 15. But in an extreme wet year the polder would still be waterlogged for 129 days. The detailed model results (IWM, 2022) show that only if the capacity of the 5 regulators is increased significantly (from one vent to up to 4 vents per regulator), the polder can achieve 88% of flood free area.

Future conditions (sea level rise, subsidence and increased monsoon rainfall) do not change the drainage situation much. Also, a reduced khal efficiency does not show a great effect on the water balance results. Both are clear indications that the number and capacity of the drain regulators is the limiting factor.

Should the polder be kept mainly for aquaculture, there is no need to improve the drainage capacity. However, there would be a need to improve the capacity to regulate the water conditions to optimize the salinity level for the shrimp or integrated shrimp-rice culture. For example, in the Shyamnagar district there are already signs that salinity in the dry season is too high for even producing salt water shrimp (Talukder et al., 2015).

It is advisable to use a water and salt balance model that simulates the storage and movement of water and salt amongst three stores in the polder: a shallow transient groundwater lens sitting on top of an underlying saltier groundwater, the soil, and canal and ponds which may store and drain water (and hence salt) from the polder (Mainuddin et al., 2021).

3.3.4 Disaster management

Using the storm surge inundation model SFINCS and the Flood Impact Assessment Tool FIAT, an estimation has been made of the cyclone storm surge risk for each polder. Details of the method and results can be found in Annex C. The risk after embankment improvement has been calculated by assuming an embankment with a safety level of 1 in 50 years under current climate conditions and 1 in 25 years in 2050. The risk profile is presented in three categories; damages (to houses, agriculture and businesses), people affected and annual mortality.

The present economic risk with the current embankment is rather high, about 2 million US$ per year (which is around 580 US$/ha per year) (Table 3-4). This comes down to an average safety level of one in 10 years (see Figure 3-10). The mortality risk due to cyclones is also high: 27 people per year. After improving the embankments, the economic risk will significantly be reduced. But the mortality risk does not reduce because casualties only occur with cyclones of 1/50 to 1/100 year probability. Both economic and mortality risk will rise in the future due to increasing cyclone hazard and sea level rise. The mortality risk will then be higher as under present conditions. This would warrant a sufficient number of cyclone shelters and early warning. There are only four cyclone shelters and the current shelter capacity is only around 10% of the polder population, which may be considered too low.

Table 3-4 Risk assessment Polder 15

15	**Initial risk (no embankment)**			**Risk with existing embankment**			**Risk after embankment improvement**		
	Damages USD/year	People affected per year	Mortality per year	Damages USD/year	People affected per year	Mortality per year	Damages USD/year	People affected per year	Mortality per year
Present	$4,225,512	3,106	44	$2,051,135	1,140	27	$706,003	500	25
2050	$4,402,750	3,250	66	$3,080,734	1,883	43	$1,391,242	996	42

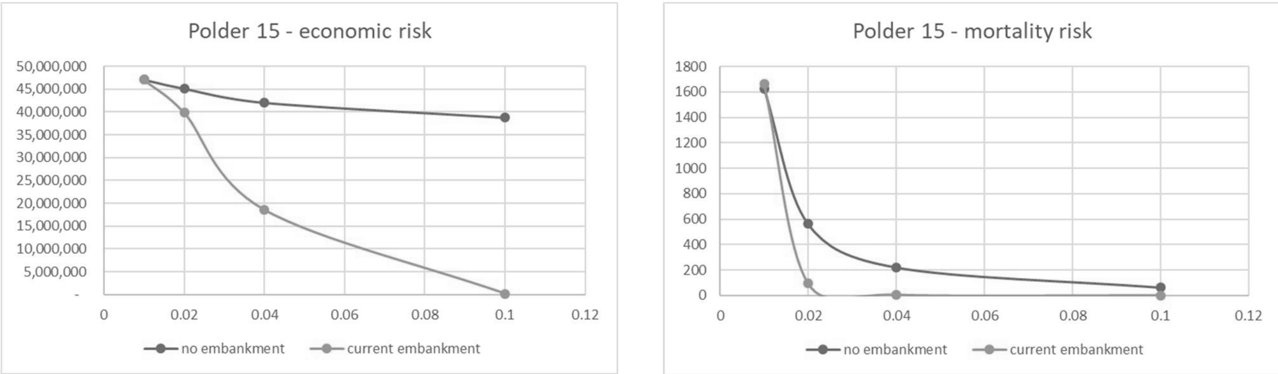

Figure 3-10 Risk profiles Polder 15 without and with current embankment (current conditions)

3.4 Cost and benefits of measures

3.4.1 Cost

Based on the above inventory of interventions a total cost estimate has been made, as presented in Table 3-5. The basis of the cost estimate are the unit prices developed for the conceptual designs that have been made for the proposed interventions. The unit prices used in the cost estimates use the specific boundary conditions of Polder 15 as described above.

Table 3-5 Cost estimation polder 15 (million US$)

Measure	**units**	**Costs (million US$)**
embankment re-sectioning (km)	23.92	8.5
retired embankment (km)	6.86	
bank protection (m)	400	23.8
slope protection (m)	4.44	
new and rehabilitation of regulators	5	1.4
khal excavation (km)	19	0.5
(new) cyclone shelters	7	5.3
Total		**39.5**

With an average shelter capacity of 1,250 people, a current population estimate of 38,866 (growth since 2011 as per SSP2 scenario) and assuming that 33% of the population should to be able to take refuge in a shelter, the total shelters needed in 2020 is 9 ((33% x 38,866)/1250). There exist 2 shelters, so 7 new shelters have to be constructed. It is assumed that future population growth does not require additional shelters as also housing conditions will improve over time.

3.4.2 Benefits

The benefits for Polder 15 consist of risk reduction from embankments, risk reductions from cyclone shelters and improved agricultural yields from improved drainage. For Polder 15 the present value[3] (PV) of the benefits are presented in Table 3-6. Based on the total costs of US$ 39.6 million and total benefits of US$ 61.2 million the investments for Polder 15 have a B/C-ratio of 1.0, which makes the proposed investments for Polder 15 feasible from an economic perspective, especially as a very large part of the investments is in the estimated length of

[3] The present value presented in the table is the value today of a discounted number of annual benefits over a period of 30 years

riverbank protection to a value of US$ 23.8 million, which is 60 % of total investments. A small reduction in length will improve the economic feasibility of the investments for Polder 15.

Table 3-6 Benefit table for polder 15

Benefit Category	**PV Benefits (million US$)**
Flood risk reduction	28.0
Risk reduction from Cyclone Shelters	7.1
Agricultural benefits	2.9
Total	**38.1**