DECCMA

Working Paper

# Biophysical and Socioeconomic State of the Indian Bengal Delta (IBD) Region of India from the Perspectives of Gender and Spatial Relations

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**Abstract**

This paper provides insights into the current socioeconomic and biophysical state of the Indian Bengal Delta (IBD), India. Hybrid and non-survey methods, notably the Flegg Location Quotient (FLQ) method of regionalization and construction of tables, are used to develop environmentally extended input-output (IO) model for comparing the economic characteristics of the IBD region and the rest of the country. The main sources of data for doing the regionalization were the Census of India and associated statistics of the catalog of the government of India, the District Handbook of the Government of West Bengal, and the Directorate General of Commercial Intelligence and Statistics (DGCIS), etc. Results from the study indicate that the agricultural and fishing sectors are more predominant in the delta than in the non-delta region. ). On the other hand, the employment in the services of public administrations, financial & insurance, in crop production and in some other industries, is higher in the rest of the country than in the delta. The work of females satisfies directly and indirectly more the final demand abroad (both in the non-delta and in the Rest of the World than the work of male). The embodied work of women in the delta is most present in services, manufactures and fishing, while being relatively less important in agriculture, energy or construction sectors.

## 1 Introduction

This Working Paper is intended to gather some insights of the baseline, the present state of this delta, studied in the project DEltas, vulnerability and Climate Change: Migration and Adaptation (DECCMA). Those insights have to do with the socioeconomic and biophysical context, with their relations and interdependencies with the economics through the supply chain up to the final demand of goods and services in the delta, in the country and in the Rest of the World (RW). The paper is structured in five sections. This section one looks at the background to the study. In the section 2, we present the context of the delta. Left in the Appendix 4 the Methodology, we place the focus on the insights for regionalization and construction of tables for the study of Deltaic areas, under the DECCMA, as summarized in Section 3. In particular, we firstly describe the general approach taken for all deltas, which consists in gathering socioeconomic and biophysical information to develop the Environmentally extended input-output (IO) tables and models, distinguishing the (DECCMA definition of the) Delta and the Rest of the country (without the delta, which for simplicity we will call "Non-Delta", while we will call "Rest of the world" the vectors referred to the exports to and imports from of other countries). Then, we focus on the particularities of the construction of the input-output table of this delta. Section 4 shows the Results, which consist of three parts. The first part is the comparison of Distribution of Value Added in the Delta and non-Delta. The second part is the Labour and gender embodiments in the final consumption of goods and services, both within the country (delta and non-Delta) and in the Rest of the world. The third part is the other environmental implications, such as the land and environmental embodiments and footprints. Section 5 presents the Conclusions and discussion.

## 2 Context

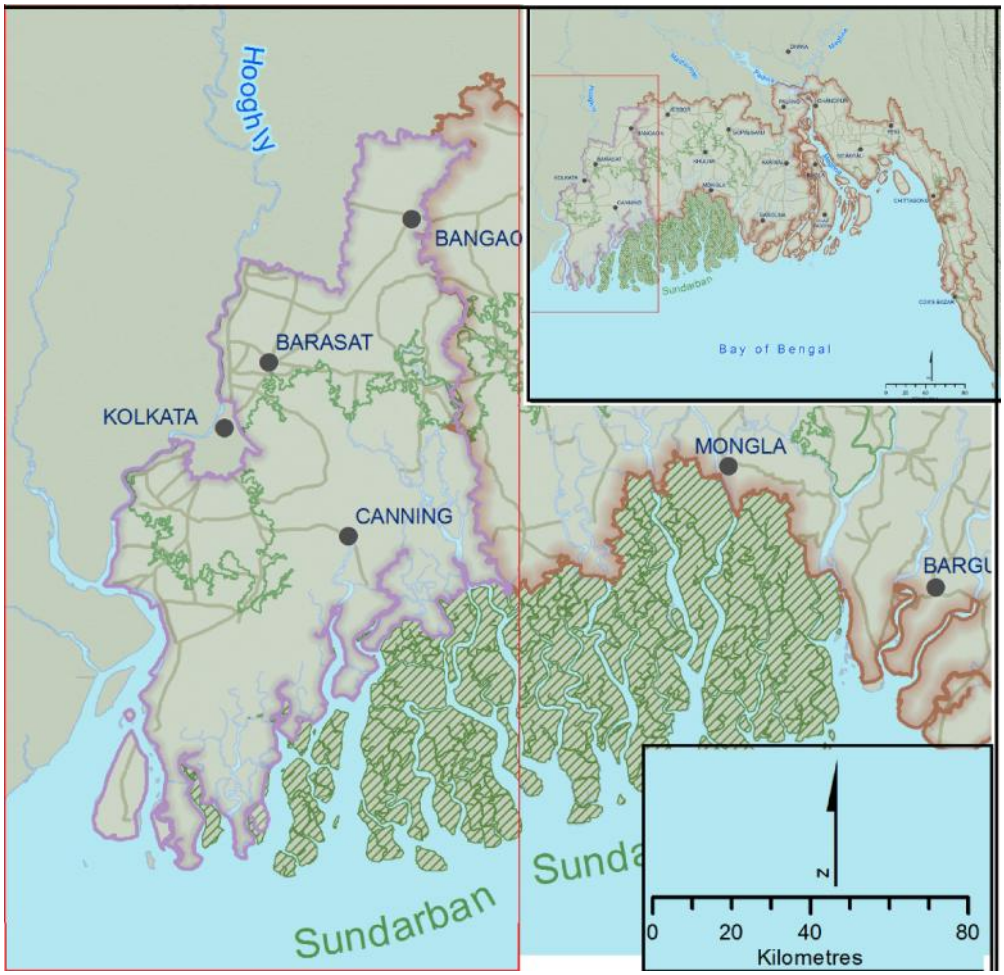
The Ganges-Brahmaputra-Meghna (GBM) Basin spans across Bangladesh, Bhutan, Nepal, China and India, and presents one of the largest estuarine regions of the world, the Sundarbans delta. The Indian Bengal (Sundarbans) Delta (IBD), lying in West Bengal, extends from latitude 21°31'58"N to 23°15'17" N and from longitude 88°1'23"E to 89°6'3"E, and comprises of two districts, North 24 Parganas and South 24 Parganas. The delta spreads over an area of 14,054 km2 (4,094 in North 24 Parganas and 9,960 in South 24 Parganas). The forest covers an area of 9,630 km2, out of which 4,264 km2 is classified as Reserve Forest (GoWB 2012b; GoWB 2012a) . The area is known for the eponymous Royal Bengal tiger (Panthera tigris tigris), as well as numerous fauna including species of birds, spotted deer, crocodiles and snakes. The other critical flora found in the region in large numbers is the Sundari trees (the mangrove species Heritiera fomes), from which the forest or the ecosystem might have obtained its name. Figure 1 shows the Physical Map of the IBD Region with the different land cover.

Temperature: The average temperature varies between 34°C (maximum) and 13.7°C (minimum). During pre-monsoon, the maximum temperature varies between 26°C and 40°C. The climate is pleasant during the winter and temperature rarely goes below 10°C. Relative humidity is over 80% from June to September and over 75% from October to May(GoWB 2012b; GoWB 2012a).

Rainfall: The climate of the Delta is humid and can be categorized into pre monsoon (February to May), monsoon (June to September), and post monsoon (October to January). The total annual rainfall is in the range of 1500 - 2000 mm. A large component of the annual rainfall (about 74% of the total) occurs during the Southwest monsoon period (June - September),

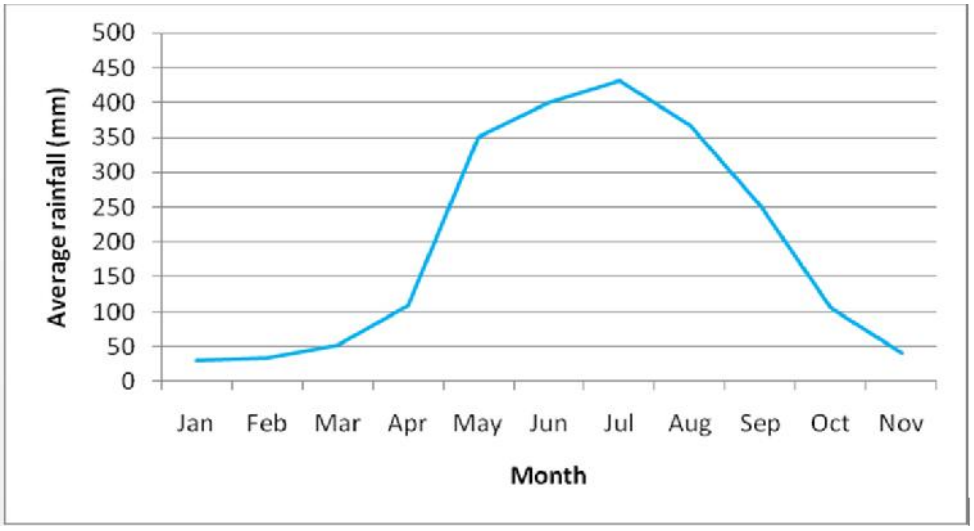
which floods the delta. As can be witnessed from Figure 2, precipitation is also received during May (i.e. the tail-end of the summer) and in October (the beginning of the post-monsoon phase).

Figure 1: Map of the IBD Region depicting the extent of our study site (region within the pink line).




Source: DECCMA WP2 team at Geodata (Southampton).

Figure 2: Long term Monthly Average (1981-2010) rainfall, IBD



Source: India Meteorological Department, Govt of India.

Winds and Cyclonic Storms: Two dominant prevailing winds during Southwest and Northeast monsoons lead to the South-westerly and the North-easterly wind. The normal maximum wind velocity is 16.7 - 50 km/hr (April - June) and minimum wind velocity is 10.7 - 11.8 km/hr (December February). The prevalence of cyclonic storms can be witnessed during April, often associated with monsoon rainfall during July and August.

The IBD lies at the tail-end of the Bhagirathi-Hooghly River, a tributary of the Ganges. This area is part of the active delta where the Hooghly, along with a number of distributaries, meet the Bay of Bengal. The interesting feature of the rivers of the delta is their changing courses and their inextricable networks. The tributaries and distributaries branches off from the mainstream, flows in a crisscross manner, and then either merges again with the main stream or merges with some other distributary thereby creating a braided drainage structure in the delta. However, the principal rivers in the system of the district are the Hooghly, Saptamukhi, Thakuran, Bidyadhari, Matla, Gosaba, Haribhanga, and Raimangal.

According to the Census 2011, the total population of North 24 Parganas is 10,009,781. On the other hand, the total population of South 24 Parganas is 8,161,961, with around 51% male population – a proportion similar to that of North 24 Parganas. The decadal growth rates of North 24 Parganas and South 24 Parganas are 12.04 percent and 18.17 percent, respectively (Table 1). The growth rate of South 24 Parganas is much higher than the growth rate of West Bengal (13.84%) during the period of 2001 and 2011. As noted earlier, sex ratios in both the districts are almost identical (955 females per '000 male), and are higher than the state-level figures of 950 per '000 male in West Bengal.

Table 1: Demographic Profile (2011).

| IBD | Rural/ Urban | Total No. of Households | Population (2011) | | | Pop.(2001) | Population Growth Rate (%) |
|---|---|---|---|---|---|---|---|
| | | | Total | Male | Female | Total | |
| **North 24 Parganas** | Total | 2,348,683 | 10,009,781 | 5,119,389 | 4,890,392 | 8,934,286 | 12.04 |
| | Rural | 993,234 | 4,277,619 | 2,196,554 | 2,081,065 | 4,083,339 | |
| | Urban | 1,355,449 | 5,732,162 | 2,922,835 | 2,809,327 | 4,850,947 | |
| **South 24 Parganas** | Total | 1,781,221 | 8,161,961 | 4,173,778 | 3,988,183 | 6,906,689 | 18.17 |
| | Rural | 1,298,259 | 6,074,188 | 3,109,219 | 2,964,969 | 5,820,469 | |
| | Urban | 482,962 | 2,087,773 | 1,064,559 | 1,023,214 | 1,086,220 | |

Source: Census of India-2001 & 2011.

Women in the IBD region commonly experience many disadvantages. They have to work hard for livelihood, and have less control over income and assets. Being poorly represented in policy and decision making, their opportunities for human development are also gradually whittled away. Women also suffer when men migrate, left to run the households with meager resources.

## 3 Methodology

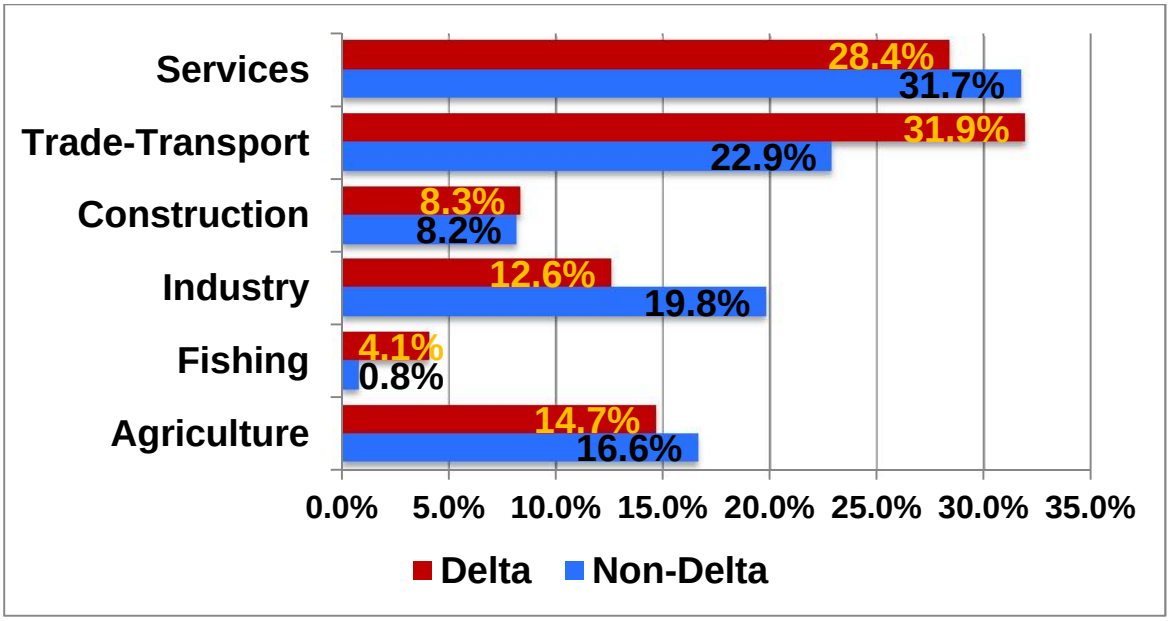
As described in detail in the Appendix 4, we place the focus on the insights for regionalization and construction of tables for the study of Deltaic areas, under the DECCMA. In particular, we firstly describe the general approach taken for all deltas, which consists in gathering socioeconomic and biophysical information to develop the Environmentally extended input-output (IO) tables and models, distinguishing the (DECCMA definition of the) Delta and the Rest of the country (without the delta, which for simplicity we will call "Non-Delta", while we will call "Rest of the world" the vectors referred to the exports to and imports from of other countries). Then, we focus on the particularities of the construction of the input-output table of this delta, such as the hybrid methods used, departing from the non-survey method of regionalization and construction of tables, the Flegg Location Quotient (FLQ) method. This is used to develop an environmentally extended input-output (IO) model for comparing the economic characteristics of the Indian Bengal Delta region and the rest of the country. This allows studying elements such as labour, gender, land, environmental embodiments and footprints. In order to study the effects of alterations such as demand changes or climate change in these areas, interdisciplinary knowledge and models were required. These allow one, for example with a classic model of Leontief demand, to see how domestic demand (households, private institutions, government etc.) and external (exports) requirements influence levels of labour and resource use, which may well find availability limits. The results then shown in the following section have been obtained using the input-output tables and the models associated to them, in particular in combination with the socioeconomic and biophysical extensions/accounts.

## 4 Results

### Distribution of Value Added

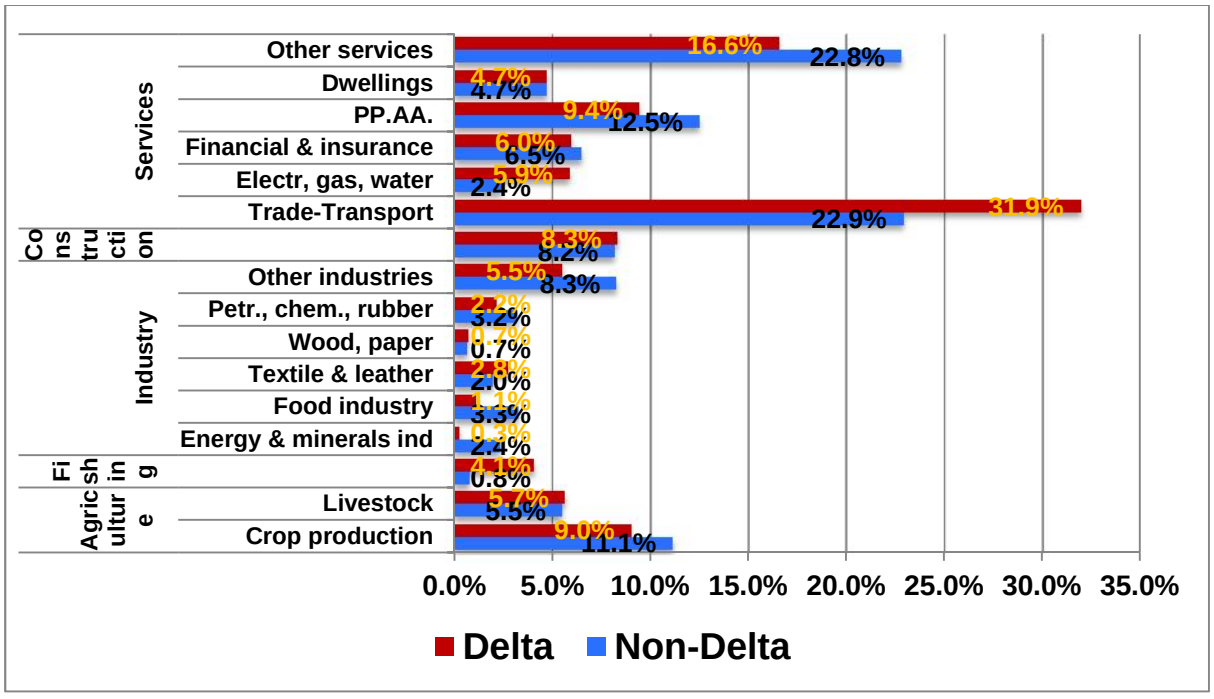
Following the methods of Appendix 4, Figure 3 and Figure 4 show the shares of value added (VA) of the main, respectively, 6 and 16 categories of sectors (from the aggregation of the 57 of GTAP 9).

**Figure 3. Distribution of Value Added by main 6 categories for the deltas.**




**Source: Own elaboration from the computation of VA in the input-output table of the Delta and Rest of the country.**

**Figure 4. Distribution of Value Added by main 16 categories for the deltas.**

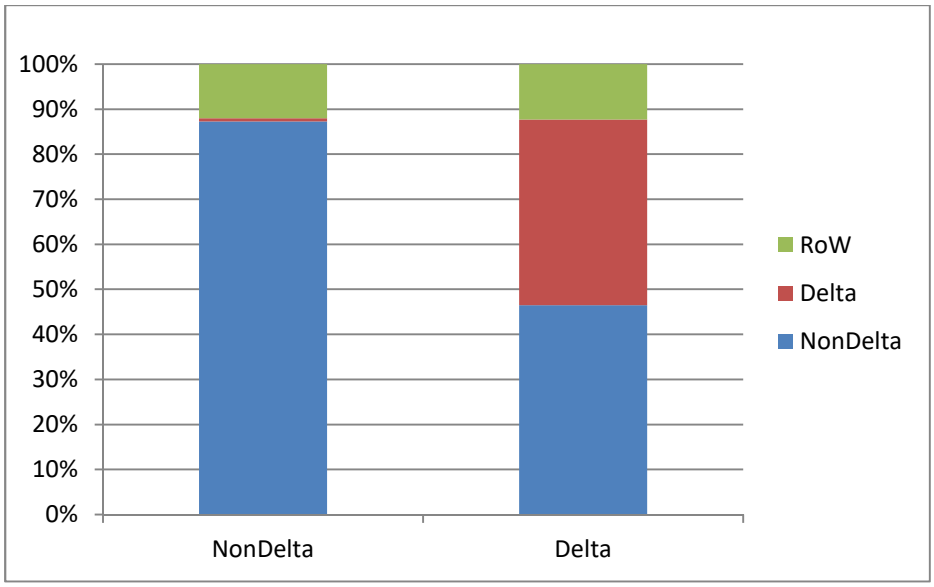



**Source: Own elaboration from the computation of VA in the input-output table of the Delta and Rest of the country.**

Figures 3 and 4 show the high importance of the agriculture sector, notably the fishing sector, which is relatively much bigger than in the rest of the country (4.1% vs. 0.8%). Also the trade and transport activities and the services sectors, and slightly the construction sector,are revealed to be relatively more important in the delta than in the rest of the country (non-delta). On the other hand, the employment in the services of public administrations, financial & insurance, in crop production and in some other industries, is higher in the rest of the country than in the delta. These results indicate the relative backwardness of these delta.

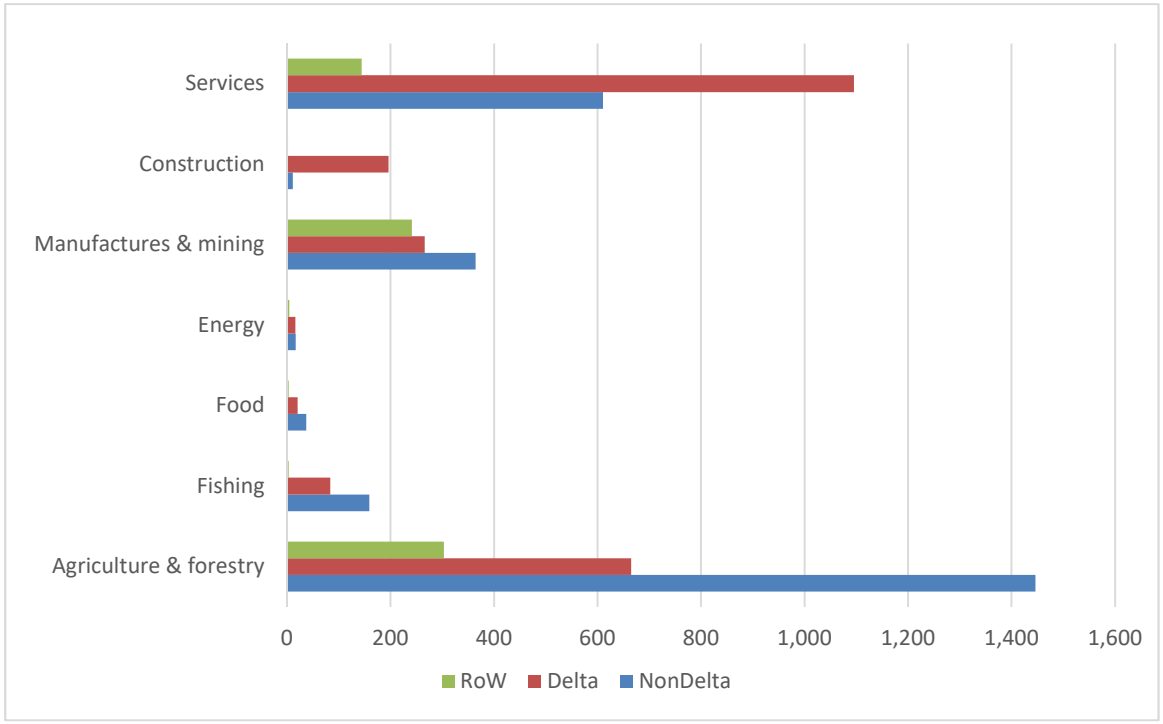
## Labour and gender embodiments

### Figure 5a. Employment of the delta by demanding region




**Source: Own elaboration from the computations with the IO table and extensions of the Delta and Rest of the country.**

### Figure 5b. Employment of the delta by demanding region and sector



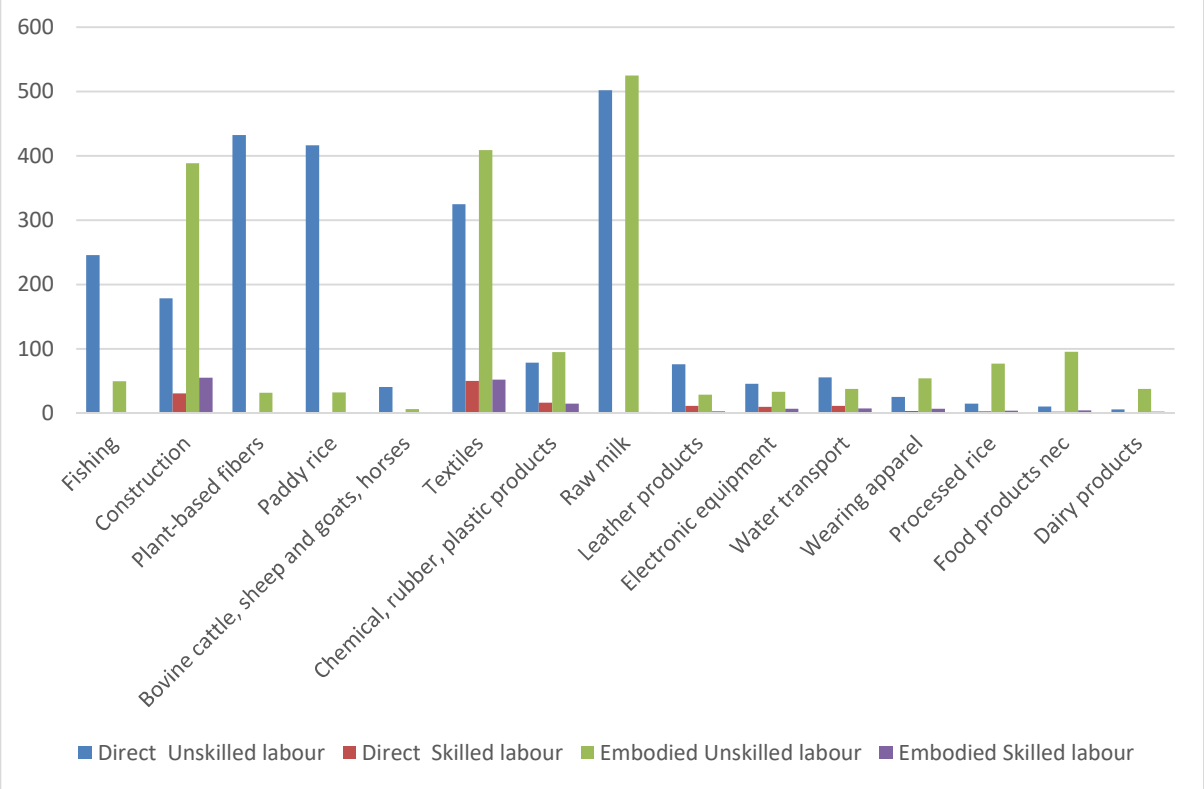

**Source: Own elaboration from the computations with the IO table and extensions of the Delta and Rest of the country.**

Figure 5a shows on the left hand side the relatively modest contribution of the delta demand in the non-delta employment (as it is a smaller area, while the employment in India is estimated for 2011 as 457,878 thousand people). Still, in absolute terms it represents an employment of

3,398 thousand (3,398K) people to satisfy the goods and services demand in the delta. On the other hand, we observe on the right hand side how the employment in the delta (5,688K people) has an important proportion (more than 45%) that is originated to satisfy the final demand of the non-delta, and a non-trivial proportion (more than 10%) that is originated to satisfy the final demand of the Rest of the World. Figure 5b shows the distribution by sector of that employment of the delta, showing that the employment in the delta has as main destination the satisfaction of the final demand within the delta itself (2,343K people, around 40%), notably in Services (1,096K people), Agriculture & Forestry (665K people), and Manufactures & mining (266K people). In the case of Services, a non-trivial number of workers (144Kpeople) satisfy the final demand in the Rest of the World. Manufactures & mining (365Kpeople) satisfy the final demand in the non-Delta, while Fishing (159K people, dominate employment to satisfy the final demand of the delta itself of 84K people) and Energy satisfy the final demand of the delta itself of 16K people.

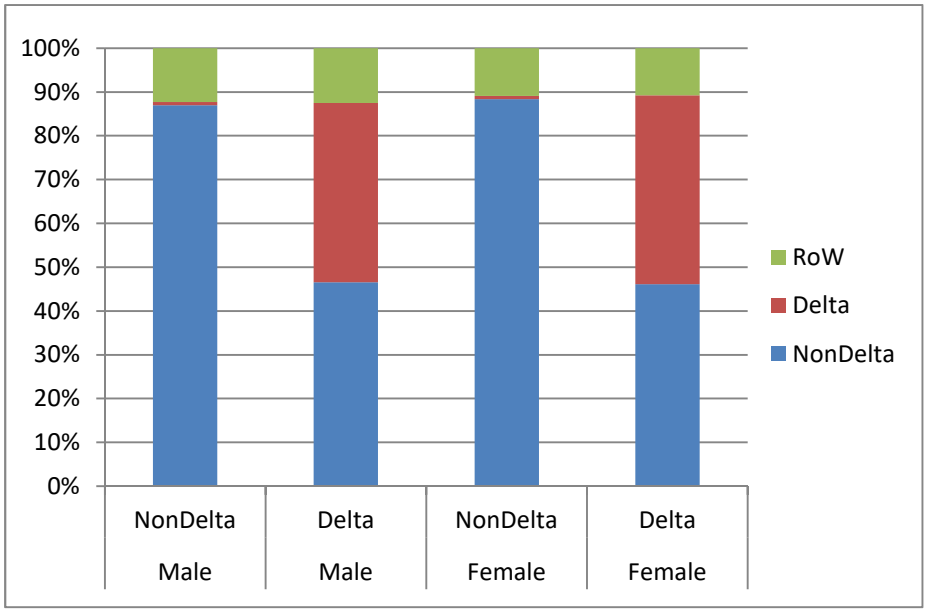
Figure 6 extends the insights obtained in Figure 5, with a sectoral and skill type (according to GTAP classification) detail. In particular, we may observe how is particularly relevant the embodied (directly and indirectly) employment in raw milk, mostly unskilled, on the textile and construction sectors. The fishing sector, mostly occurring to satisfy the (exports) final demand of the non-delta (also partly the RW), or Plant-based fibers and paddy rice, although they have important direct employment levels, they embody less employment in their final goods sold to final demand than others such as Food products nec., Processed rice, Chemical, rubber, plastic products; or Leather products.

**Figure 6. Direct and embodied labour of the delta by sector**



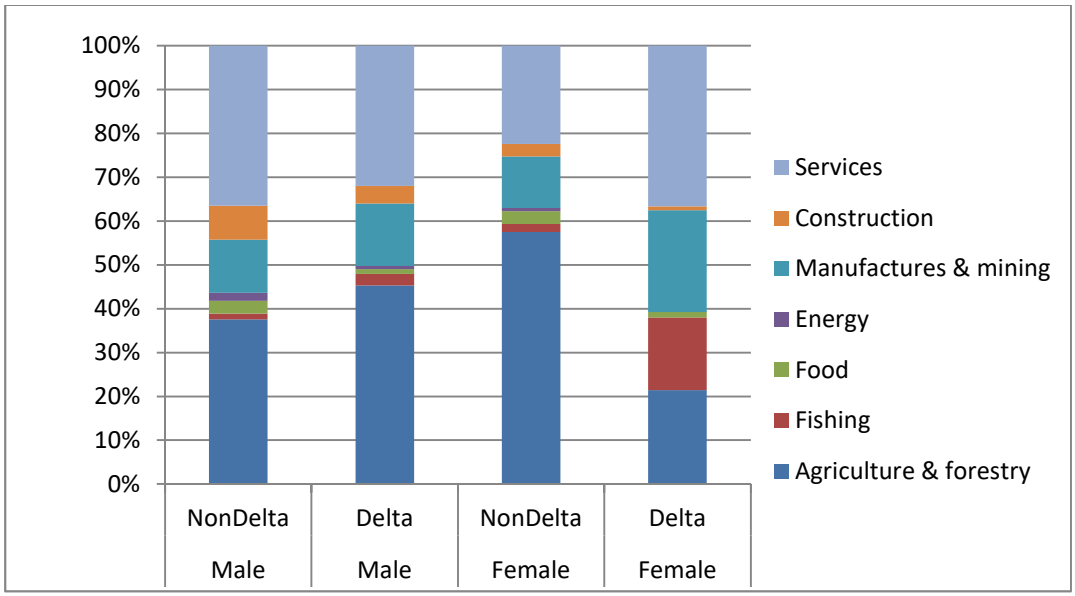
**Source: Own elaboration from the computations with the IO table and extensions of the Delta and Rest of the country.**

### Figure 7a. Employment by gender & sector of the Non-Delta and Delta by demanding region




**Source: Own elaboration from the computations with the IO table and extensions of the Delta and Rest of the country.**

### Figure 7b. Direct and embodied labour by sector and gender in the Non-Delta and Delta




**Source: Own elaboration from the computations with the IO table and extensions of the Delta and Rest of the country.***

Figures 7a and 7bextend the insights obtained in Figures 5 and 6, by providing the gender detail of this employment. We may observe in Figure 6a how the work of females satisfies directly and indirectly more the final demand abroad (both in the non-delta and in the Rest of the World) than the work of male. In Figure 7b we observe the embodied work of women in the delta mostly in the services, manufactures and fishing, while being relatively less important in agriculture, energy or construction sectors.

**Figure 8a. Embodied labour by sector and skill type (GTAP classifications)**

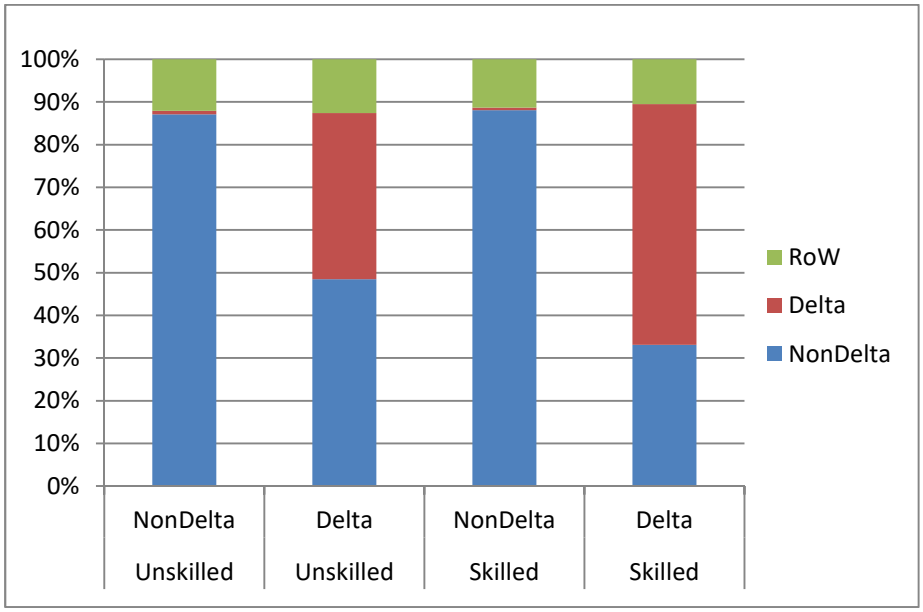
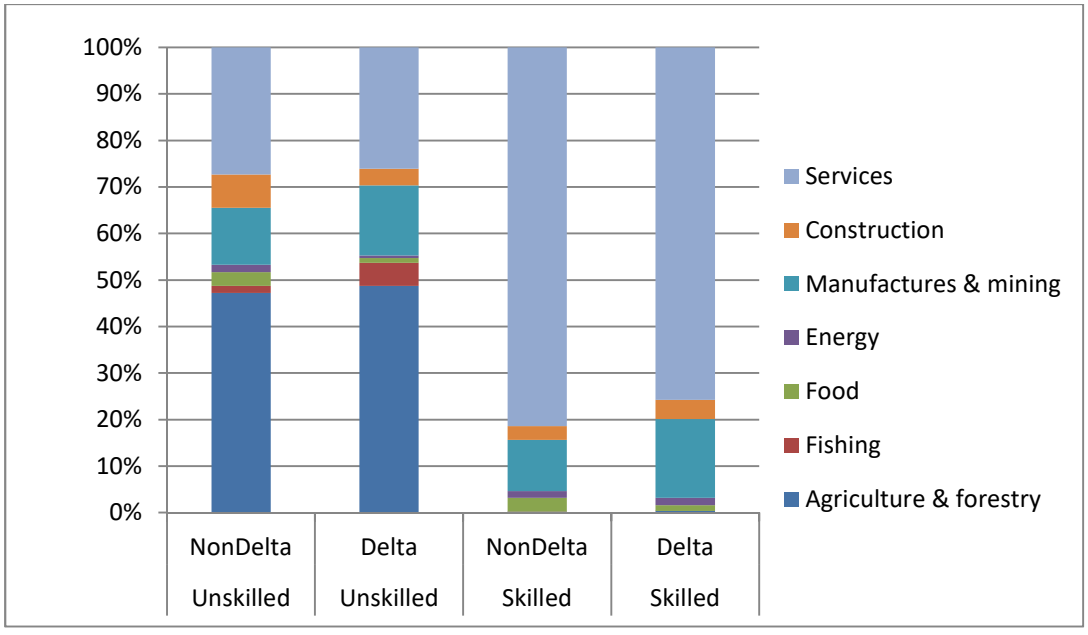



**Figure 8b. Embodied labour by sector and skill type (GTAP classifications)**



**Source: Own elaboration from the computations with the IO table and extensions of the Delta and Rest of the country.**

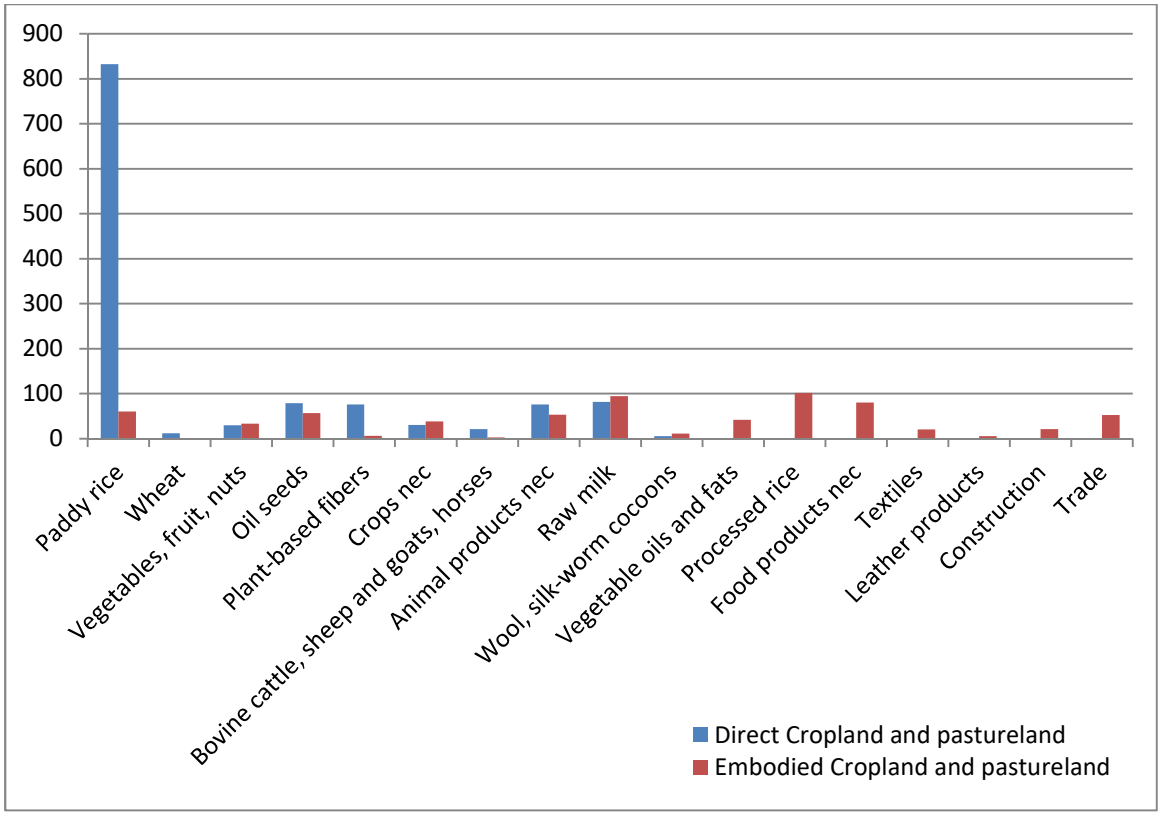
Figures 8a and 8b extends the insights obtained in Figures 5, 6 and 7, by providing the detail of this employment by skill type (according to the GTAP classifications). We may observe in Figure 8a how in the delta, the skilled work satisfies directly and indirectly less the final demand abroad (both in the non-delta and in the Rest of the World) than the unskilled work. In Figure 8b we observe the dominance (with respect to the unskilled work) of skilled work in the delta embodied in the services and energy, while being relatively less important in agriculture, fishing and the construction sectors. In the non-delta, the construction sector has more share of employment than in the delta, and interestingly, less in agriculture (when the share of value added is relatively higher). The latter outcome may be due to higher labour and / or land productivity or prevalence of more efficient technology in non-delta areas.

**Land and environmental embodiments and footprints**

The environmental extensions allows for the computation of many embodiments and footprints, which we illustrate, as an example, for the case of land use (in physical units) in Figure 9.

Figure 9 examines, analogously to the analysis of labour in Figure 6, the embodiment of agricultural land of the delta in the demanding regions (delta; non-delta and Rest of the World). The direct agricultural land use is clearly dominated by paddy rice (above 800K hectares), but this changes enormously when we look at the embodied agriculture land in the final demand of goods and services. In particular, we may observe how the embodied land use in the raw milk is particularly relevant, mostly occurring to satisfy the (exports) final demand of the non-delta (also partly the RW). We also observe how sectors not directly using agricultural land the most, such as food industry sectors and trade, have notable embodied (directly and indirectly) agricultural land levels.

**Figure 9. Direct and embodied Cropland and pasture land (1000 hectares) of the delta**




**Source: Own elaboration from the computations with the IO table and extensions of the Delta and Rest of the country.**

### Table 2. Summary of import, export and footprints

| | Direct in production | Embodied exports | Embodied imports | Net trade (E-M) | Footprint |
|---|---|---|---|---|---|
| **Delta. Employment (1000 people)** | **5,688** | **3,346** | **2,923** | **423** | **5,265** |
| **Delta. Land (1000 hectares)** | **1,670** | **1,204** | **778** | **426** | **1,244** |
| **Delta. Energy (Mtoe)** | **1.6** | **0.9** | **1.5** | **-0.6** | **2.2** |
| **Delta. CO2(Mt CO2)** | **10.9** | **5.9** | **9.5** | **-3.6** | **14.5** |
| **Non-Delta. Employment (1000 people)** | **451,111** | **57,560** | **56,986** | **574** | **450,537** |
| **Non-Delta. Land (1000 hectares)** | **219,385** | **25,507** | **25,169** | **339** | **219,046** |
| **Non-Delta. Energy (Mtoe)** | **258** | **62** | **61** | **1** | **257** |
| **Non-Delta. CO2 (Mt CO2)** | **1,301** | **236** | **231** | **5** | **1,296** |

**Source: Own elaboration from the computations with the IO table and extensions of the Delta and Rest of the country.**

Table 2 summarizes the direct uses (of resources) or impacts (CO2 emissions) in production; embodied exports and imports (whose difference is the virtual net trade) and the footprint (the embodied use or impact in the final demand of the households of the area –delta or Rest of the country). The delta is net exporter of employment and agricultural land, embodied in goods and services sold to other regions (higher than in imports), but net importer of energy and CO2 emissions.

Table 3 summarizes the embodied exports and imports between the delta area and the Rest of the country. In this preliminary version of the table, the delta results net importer of all the variables considered: employment, land, energy, CO2 emissions, embodied in goods and services bought from other regions (higher than in exports).

**Table 3. Summary of import, export and footprints only between the delta area & the Rest of the country**

| | Direct in production | Embodied exports | Embodied imports | Net trade (E-M) |
|---|---|---|---|---|
| **Delta. Employment (1000 people)** | **5,688** | **2,645** | **3,398** | **-752** |
| **Delta. Land (1000 hectares)** | **1,670** | **1,078** | **1,942** | **-864** |
| **Delta. Energy (Mtoe)** | **2** | **0.6** | **2.1** | **-1.5** |
| **Delta. CO2(Mt CO2)** | **11** | **4.7** | **11.7** | **-7.1** |
| **Non-Delta. Employment (1000 people)** | **451,111** | **3,398** | **2,645** | **752** |
| **Non-Delta. Land (1000 hectares)** | **219,385** | **1,942** | **1,078** | **864** |
| **Non-Delta. Energy (Mtoe)** | **258** | **2.1** | **0.6** | **1.5** |
| **Non-Delta. CO2 (Mt CO2)** | **1,301** | **11.7** | **4.7** | **7.1** |

**Source: Own elaboration from the computations with the IO table and extensions of the Delta and Rest of the country.**

## 5 Conclusions and discussion

This Working Paper has tried to gather some insights of the baseline, the present state of this delta, studied in the project DEltas, vulnerability and Climate Change: Migration and Adaptation (DECCMA). Those insights have to do with the socioeconomic and biophysical context, as we have shown with the analyses of employment and environmental embodiments and footprints. The input-output (IO) table and model have shown and used interdependencies through the supply chain up to the final demand of goods and services in the delta, in the country and in the Rest of the world.

Key results are the strong importance of the agriculture sector, notably the fishing sector, which is relatively much bigger than in the rest of the country (4.1% vs. 0.8%). Also the trade and transport activities -which quite often go unnoticed when highlighting important sectors of the deltas, such as small business, trade, etc.- are revealed to be relatively more important in the delta than in the rest of the country (non-delta). On the other hand, the employment in the services of public administrations, financial & insurance, in crop production and in some other industries, is higher in the rest of the country than in the delta implying relative backwardness of the delta region. The work of females satisfies directly and indirectly more the final demand abroad (both in the non-delta and in the Rest of the World than the work of male). This is probably because in this delta the work of female is normally used in activities that require female specific skill (like collection of prawn seeds) and the resulting output are mostly export oriented intermediate inputs. The embodied work of women in the delta is most present in services, manufactures and fishing, while being relatively less important in agriculture, energy or construction sectors. The main skilled work in the delta is embodied in the services and

energy, while being relatively less important in agriculture, fishing and the construction sectors. In the non-delta, the construction sector has more share of employment than in the delta, and interestingly, less in agriculture (when the share of value added is relatively higher).

The results on land uses how that although agricultural land use is clearly dominated by paddy rice (above 800K hectares), this changes enormously when we look at the embodied agriculture land in the final demand of goods and services. In particular, the embodied land use in the raw milk is particularly relevant, and also in sectors not directly using agricultural land the most, such as food industry sand textile. All in all, the delta is net exporter of employment and agricultural land (also in particular only with respect to the rest of the country), embodied in goods and services sold to other regions (higher than in imports), but net importer of energy and CO2 emissions.

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## Appendices

### Appendix 1. Codes

Lab: All other workers (previously classified as unskilled in GTAP 8), mgr: Managers and professionals, tec: Technicians and associate professionals, clk: Clerical support workers, srv: Service and sales workers.

### Appendix 2. The Delta definition

Districts: North 24 Parganas and South 24 Parganas.

### Appendix 3. The Delta input-output table (aggregated to the main sectors) (Mio USD)

| | Non-Delta. Agriculture | Non-Delta. Industry | Non-Delta.Rest (Construction and Services) | Delta. Agriculture | Delta. Industry | Delta.Rest (Construction and Services) | Non-Delta.FD | Delta |
|---|---|---|---|---|---|---|---|---|
| Non-Delta.Agriculture | 59,145 | 119,269 | 25,596 | 341 | 298 | 269 | 224,031 | 1,797 |
| Non-Delta.Industry | 44,953 | 473,551 | 243,531 | 357 | 1,348 | 2,125 | 553,101 | 5,034 |
| Non-Delta.Rest (Construction & Services) | 30,029 | 242,564 | 244,662 | 163 | 765 | 1,330 | 1,017,865 | 5,138 |
| Delta.Agriculture | 127 | 410 | 46 | 560 | 506 | 116 | 1,960 | 1,084 |
| Delta.Industry | 66 | 604 | 288 | 134 | 1,962 | 709 | 1,894 | 2,013 |
| Delta.Rest (Construction & Services) | 87 | 650 | 628 | 188 | 1,061 | 2,305 | 3,006 | 10,04 |
| Imports | 7,161 | 343,509 | 75,058 | 24 | 488 | 244 | 162,630 | 1,639 |
| VA | 302,369 | 385,857 | 1,048,888 | 3,268 | 2,654 | 11,521 | 42,608 | 429 |
| **Total** | **443,937** | **1,566,414** | **1,638,696** | **5,035** | **9,083** | **18,618** | **2,007,095** | **27,17** |

* Representation of the commercial account balance.

The results on land uses how that although agricultural land use is clearly dominated by paddy rice (560K hectares), this changes enormously when we look at the embodied agriculture land in the final demand of goods and services. In particular, the embodied land use in the raw milk is particularly relevant, and also in sectors not directly using agricultural land the most, such as food industry sand textile. All in all, the delta is net exporter of agricultural land (also in particular only with respect to the rest of the country), embodied in goods and services sold to other regions (higher than in imports), but net importer of employment, energy and CO2 emissions.

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| | Non-Delta. Agriculture | Non-Delta. Industry | Non-Delta.Rest (Construction and Services) | Delta. Agriculture | Delta. Industry | Delta.Rest (Construction and Services) | Non-Delta.FD | Delta.FD | Exports | **Total** |
|---|---|---|---|---|---|---|---|---|---|---|
| Non-Delta.Agriculture | 59,822 | 120,290 | 25,948 | 102 | 90 | 42 | 226,847 | 966 | 13,355 | **447,461** |
| Non-Delta.Industry | 45,447 | 476,552 | 246,143 | 54 | 290 | 375 | 559,300 | 2,080 | 243,340 | **1,573,583** |
| Non-Delta.Rest (Construction & Services) | 30,423 | 245,172 | 248,410 | 71 | 129 | 244 | 1,031,110 | 1,270 | 97,038 | **1,653,868** |
| Delta.Agriculture | 53 | 164 | 19 | 72 | 69 | 12 | 533 | 570 | 18 | **1,512** |
| Delta.Industry | 21 | 219 | 110 | 18 | 197 | 74 | 317 | 670 | 288 | **1,913** |
| Delta.Rest (Construction & Services) | 17 | 134 | 132 | 13 | 95 | 117 | 410 | 2,455 | 73 | **3,446** |
| Imports | 7,127 | 343,139 | 74,904 | 53 | 586 | 323 | 163,017 | 1,643 | -590,791 | **0** |
| VA | 304,550 | 387,913 | 1,058,202 | 1,129 | 457 | 2,259 | 42,656 | 430 | 236,680 | **2,034,274** |
| **Total** | **442,971** | **1,573,583** | **1,653,868** | **6,001** | **1,913** | **3,446** | **2,021,855** | **12,419** | **0** | **5,716,058** |

* Representation of the commercial account balance.

## Appendix 4. Methodology

### General approach of the (labour, gender, land, environmental) embodiments and footprints

The general approach taken for this Working Paper is an environmentally (the socioeconomics are already there) extended input-output model. This allows studying elements such as the labour, gender, land, environmental embodiments and footprints. To study the effects of alterations such as demand changes or climate change in these areas, require interdisciplinary knowledge and models. This one allows, for example with a classic model of Leontief demand (Leontief 1936, 1941, 1974; Miller and Blair 2009; Leontief 1970), to see how domestic demand (households, government, ... ) and external (exports) requires certain levels of labour and resources, which may well find availability limits (obviously generating growth limits, etc.) .

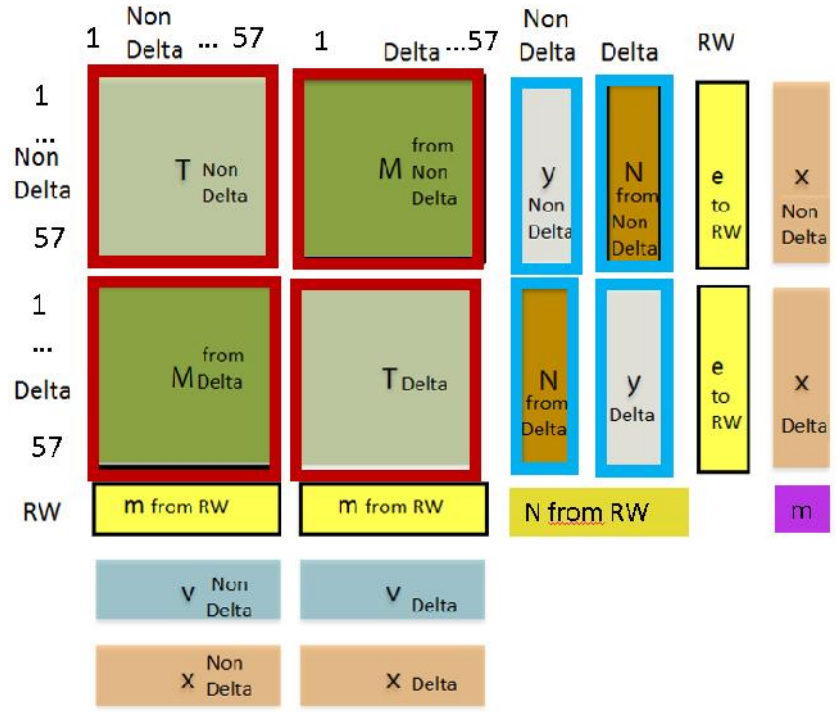
Developing regional tables and extensions of specific Deltaic areas, not matching the economic or political boundaries poses additional challenges, so we focus on.

- Exploration and description of the structure of the economies studied.
- Information directed towards the larger or most important elements of the economies studied and the inclusion of boundaries on some flows.
- The choice of the departure matrix of a surrounding country or region, with an economy similar to the one under consideration and the analysis of the problem of zero location.
- When having to use neighbouring or different scale IO data, identifying similarities rather than differences in regions economic structures.
- The (mis-)match between the political, economic and natural resources (in particular the hydrology defining the Deltas) boundaries and data.

### Scheme of delta and non-delta input-output table and equations for the model

The scheme generates the multiregional input-output table for the delta, the rest of the country and the world, is shown in Figure ***A4*** , where the set of red squares representing transactions of intermediate goods $\mathbf{Z} = (z_{ij})$ and set of blue boxes represent the matrix and **Y** is the vector of final demand.

**Figure *A4*: MRIO for the Delta and Non-Delta regions.**




Source: Adapted from(Kanemoto et al. 2011; Lenzen et al. 2013).

Where **T** are the Intermediate Domestic matrices, **M** the Intermediate import matrices, **y** the final demand excluding exports of final goods and services to the other region, **N** the final demand of exports (or imports respectively for each region) of goods and services from the other region in the same country, **e** are the column vectors of the exports of each of the regions to the Rest of the World (RW), **m** are the row vectors of the imports of each of the regions from the RW, **x** is total gross output, and **v** is the Value Added/Primary Input.

Departing from the basic model of Leontief: $\mathbf{x=Ax+y} \leftrightarrow \mathbf{x=(I-A)^{-1}y}$ (1)

Where $x_i$ is the gross output of good i; **x** the vector of outputs of the economy; $y_i$ the final demand of goods i; **Y**the matrix of final demand column vectors; $\mathbf{A}=\left(a_{ij}\right)$ the matrix of technical coefficients of the multiregional table indicated above, defined as $a_{ij}=x_{ij}/x_j$ $a_{ij}=z_{ij}/x_j$; finally, $\mathbf{L=(I-A)^{-1}}$ is the called Leontief inverse. Being **r**=($r_i$) a vector of unitary coefficients of resource (or "input") or impact (employment, land, water, CO2, etc.) per unit of output, we obtain the multipliers, that is to say, the amount of resource directly or indirectly (embodied) per unit of final demand:

$\boldsymbol{\omega=r'(I-A)^{-1}}$ (2)

So when postmultiplying these values, the directly and indirectly "required" amounts (used) are obtained, verifying that:

$\mathbf{r'x=r'(I-A)^{-1}y=\grave{u}'y}$ (3)

All in all, this system allows for consistently (avoiding double-counting, etc.) measuring the direct and indirect social and environmental requirements for the goods and services supplied to the consumers.

**Data and regionalization method for the construction of the input-output table**

We use the most recent dataset from the Global Trade Analysis Project (GTAP) version 9 with detailed accounts of regional production and consumption, bilateral trade flows, land use, energy flows, and CO2 emissions, all for the base year 2011 (Narayanan et al. 2015). The GTAP database is aggregated toward a composite dataset that accounts for the specific

regional requirements of our analysis. Regarding the data regionalization and update, we first choose the departure matrix of a country, surrounding or neighbouring region with an economy similar to the one under consideration, which in this case is the country table for 2011 of GTAP 9. We follow one of the most popular regionalization methods, variants of the Simple Location Method (SLQ) method[1], which have been recently developed and defended as superior to many other, the Flegg's Location Quotient (FLQ), see (Tohmo 2004; Flegg and Webber 1997, 2000; Flegg et al. 1995; Flegg and Tohmo 2013)(Kowalewski 2012). These works have shown the advantages of this method (e.g. improving the SLQs –only accounting for the selling sector- and Cross Industry Local Quotient, CILQ –considering the selling and purchasing sector, but useless for the main diagonals). In order to use this method, and regionalize to the delta the original national table and data of intermediate transactions, the employment and production totals by sector are the main data. Then, completing other parts of the table with "real" or specific delta data (e.g. the rows of employment, land use, etc., and columns of household consumption, government, exports, etc.), this "real" or ''superior'' data is added to make the best use of the available local data and avoid possible biases.

**Particularities of the construction of the input-output table of this delta**

The key and very complete information that allows completing many vectors of the IO table and doing the regionalization is (GoWB 2012a; GoWB 2012b)). Also some information is obtained by (PCA, 2011), and then the rest is complemented with other information, such as from (Ghosh and Chaudhuri 2012; TEEB 2010), or (Guha and Ghosh, 2009). Key information such as that of the District Statistical Handbook or the Agricultural data is also referenced from (GoWB 2012a; GoWB 2012b) , since we got a complete dataset of the North 24 Parganas and South 24 Parganas from the Government of West Bengal.

With these tables, for the IBD delta in India, a RAS type approach is performed to apportion the employment by category (skill) type, gender and sector (each of the 57 sectors). On the one hand, we have the employment by district and gender (male/female) for the main 12activities/sectors (Cultivators; Agricultural labourers; Plantation, Livestock, Forestry, Fishing, Hunting and allied activities; Mining and Quarrying; Manufacturing; Electricity, Gas and Water Supply; Construction; Wholesale and Retail Trade; Hotels and Restaurants; Transport, Storage and Communications; Financial Intermediation, Real Estate, Renting and Business Activities; Public Administration, Other Community, Social and Personal Service Activities, Private Households with Employed Persons), which are split to 57 (the agricultural sector is disaggregated based on the particular info; while the rest of the sectors are split in the same proportion than the equivalent split of 12 to 57 at the national level of India, which is given in the Labour force survey that the ILO gathers, (ILO 2015). At the national level, some small corrections are applied to the employment data in order to obtain (as the ratio of the labour rows in GTAP and the employment of people) reasonable wages, when they do not reach a minimum of 40$ per year (e.g. as it occurs with the original data of the wage of unskilled labour in the transport sectors) or exceed the maximum of 200,000$per year (e.g. as it occurred with the original data of the wage of the Dwellings sector).

Other key data for the construction of the IO table, in particular the agricultural sector, are the agricultural land uses, production, prices, data of livestock, fisheries, etc.

[1]Several studies among the earliest ones identified and defended the Simple Location Quotient method (Schaffer and Chu 1969a, 1969b; Morrison and Smith 1974; Eskelinen and Suorsa 1980; Sawyer and Miller 1983).

Then the Social Accounting Matrix (SAM) is obtained from the regionalization of transfers and institutional (government, households, societies) interrelations, both at the national (already in GTAP 9) and delta levels. Data on the public sector is also complemented from other public data.

The data on geography, climate and environment is obtained from several sources such as (Danda et al. 2011), (Chaudhuri and Choudhury 1994), (SDMBRI 1996; Sarkar and Bhattacharya 2003), (Hazra et al. 2002), (Hazra 2010), (Singh 2007).