DECCMA

Working Paper

Biophysical and Socioeconomic State of the Mahanadi Delta Region of India from the Perspectives of Gender and Spatial Relations

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About DECCMA Working Papers

This series is based on the work of the Deltas, Vulnerability and Climate Change: Migration and Adaptation (DECCMA) project, funded by Canada's International Development Research Centre (IDRC) and the UK's Department for International Development (DFID) through the **Collaborative Adaptation Research Initiative in Africa and Asia (CARIAA)**. CARIAA aims to build the resilience of vulnerable populations and their livelihoods in three climate change hot spots in Africa and Asia. The program supports collaborative research to inform adaptation policy and practice.

Titles in this series are intended to share initial findings and lessons from research studies commissioned by the program. Papers are intended to foster exchange and dialogue within science and policy circles concerned with climate change adaptation in vulnerability hotspots. As an interim output of the DECCMA project, they have not undergone an external review process. Opinions stated are those of the author(s) and do not necessarily reflect the policies or opinions of IDRC, DFID, or partners. Feedback is welcomed as a means to strengthen these works: some may later be revised for peer-reviewed publication.

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Abstract:

This paper provides insights into the current socioeconomic and biophysical state of the Mahanadi Delta, India. 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 Mahanadi Delta 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 Odisha Government Statistics and the Economic Surveys, and the Directorate General of Commercial Intelligence and Statistics (DGCIS), etc. Results from the study indicate that the agricultural sector, trade and transport activities, and notably fishing are much predominant in the delta than in the non-delta region. On the other hand, the employment in most other services, financial & insurance and in some other industries, is clearly higher in the rest of the country than in the delta. The work of females satisfies directly and indirectly less 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, and also (probably surprising) in the construction sector, while being relatively less important in agriculture, energy.

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.

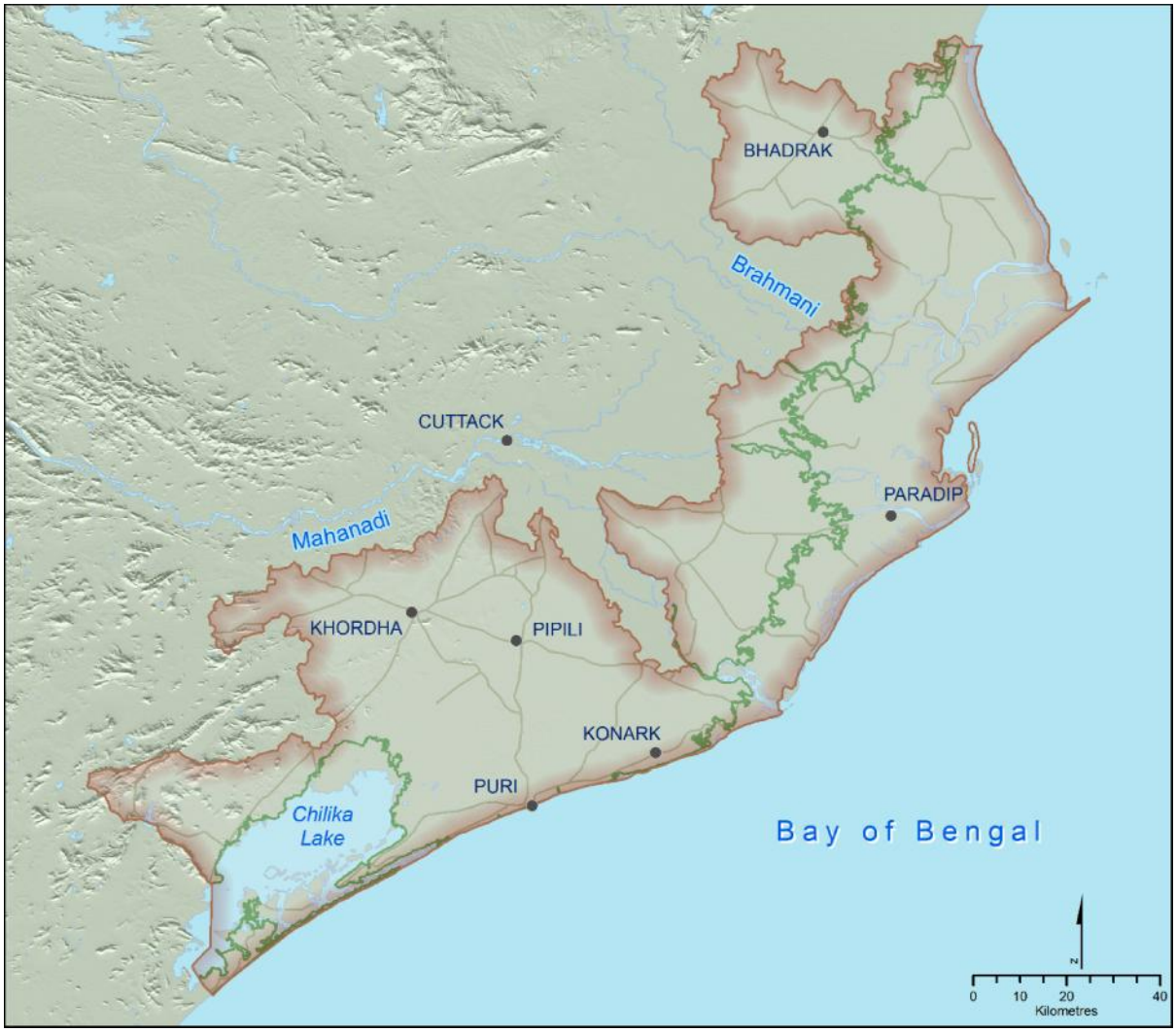
2 Context

The Mahanadi Delta (MD) is drained by the network of three major rivers: Mahanadi, Brahmhani and Baitarini into Bay of Bengal. The coastline of the delta is about 200 km long which stretches from south near Chilika to north up to Dharma River. The delta covers an area of nearly 95000 Km^2 and the upper part of the delta is highly populated. Sediment carrying rivers generally form delta near the mouth where geologic, tectonic, geographic, climatic and environmental settings are suitable for formation. The Mahanadi River is one of them. The River starts building up its delta plain from Naraj where the undivided Mahanadi branches forming its distributary system in the delta plain area. Mahanadi Delta is one of the largest deltas on the east coast of India.

The Mahanadi delta experiences a tropical with hot and humid monsoonal climate. The delta receives an average annual rainfall of 1572 mm of which over 70% is precipitated during the southwest monsoon between middle of June to middle of October (Fig 1). The first week of June is the normal time of onset of monsoon over the delta. The amount of rainfall receives in January to February is less than 50 mm. The mean summer temperature of the region varies near 29^{o}C and winter temperatures near 21°C.

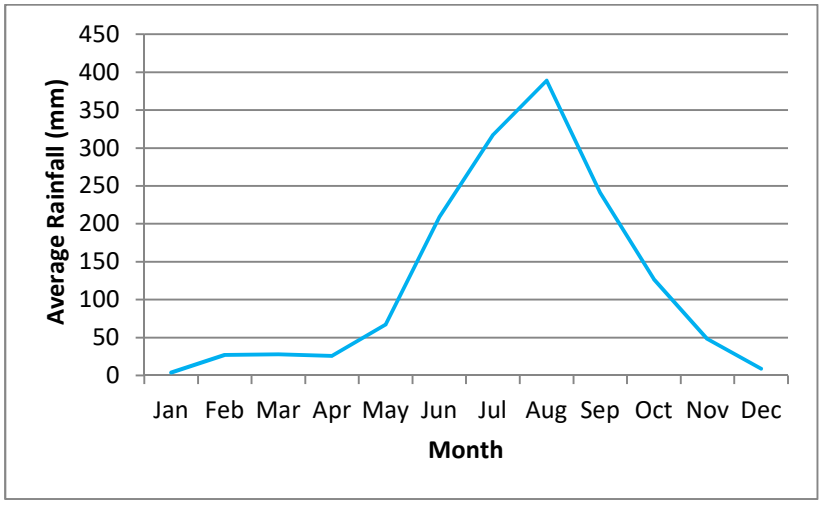
The Mahanadi River originates from Raipur district of Chhatisgarh and flows for about 851 km before it drains into the Bay of Bengal. Its main tributaries are the Seonath, the Jonk, the Hasdeo, the Mand, the ib, the Ong and the Tel. Other distributaries of Mahanadi include the Paika, Birupa, Chitroptala River, Genguti and Lun. Birupa later joins the Brahmani River at Khushnanagar. The annual discharge of Mahanadi River measured at Naraj is 48691million cubic metres.

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



Source: DECCMA WP2 team at Geodata (Southampton).

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



Source: India Meteorological Department, Govt of India.

The basin has an extensive area under agricultural use. Forest and agriculture are the main stay of the people in the interior parts of the basin. The upper part of the delta is highly populated in respect to the lower part of the delta. The areal distribution of land use pattern of the delta is portrayed in Fig.2 and the district wise details are given in Table 1. The Mahanadi Delta has subsurface features of depression and ridges. Most of the ridges are covered with forest and low lying area under cultivation and human settlement. The land use practice in this delta changes over time depending upon the sedimentation and morphology dynamics. Devastating floods in the delta continuously bring about some changes in land use pattern. The Chilika Lake, the largest coastal lagoon in Asia is situated in the far south of the delta.

The DECCMA delta definition comprises five districts (Puri, Kendrapara, Bhadrak, Jagatsingpur, Khurda) of Odisha under our study area of Mahanadi Delta based on the 5m contour line. As per the 2011 Census the total population is around 8.03 million. Out of the total population in these five districts Khordha has the highest population (28.03%) and Jagatsingpur has the Lowest Population (14.15%). In terms of density Khorda (817persons/ Sq Km) is in the top position and Puri (485 persons/ Sq Km) is in the lowest. In these five districts 50.9% are male and 49.1% are female population. As per the age specific characterization Khordha has the highest population (27.40%) under six years age whereas Jagatsingpur district has the lowest population (12.73%) for the same stratum. As per the 2011 Census Report 18.86% of total population in the five districts is the Scheduled Caste population and 2.10% are the Scheduled Tribe population. Out of the selected five coastal districts Bhadrak has the highest Scheduled Caste population (22.10%) whereas Khorda has the highest Scheduled Tribe population (68.10%). In terms of Literacy in the coastal districts, 76.10% population are literate and out of these literate persons 54.3% are male and 45.7% are female and Khordha has the highest male and female literate persons. In terms of employment, only 34.27% are working in different sectors in the coastal districts and out of these 82.31% are male and only 17.69% are female. Out of the total working population only 13% are engaged in Agriculture and Cuttack has the highest agriculture cultivator in the selected coastal districts.

Table 1: Demographic Profile (2011).

Name	Area in Sq Km	Density	Total pop.*	% of Total pop.*	Total Male pop.*	% of Total Male pop.*	Total Female pop.*	pop.* under 06 years of Age	% of pop.* under 06 years of Age	pop.* under Schedule cast category	% of pop.* under Schedule cast category	pop.* under Schedule Tribe Category	% of pop.* under Schedule Tribe Category
Puri	3501	485.2	1698730	21.14	865380	21.17	833350	172888	19.96	325133	21.45	6129	3.63
Bhadrak	2451	614.6	1506337	18.75	760260	18.60	746077	184560	21.31	334896	22.10	30428	18.01
Kendrapara	2480	580.8	1440361	17.93	717814	17.56	722547	161159	18.60	309780	20.44	9484	5.61
Jagatsinghapur	1669	681.2	1136971	14.15	577865	14.13	559106	110249	12.73	248152	16.37	7862	4.65
Khordha	2755	817.3	2251673	28.03	1167137	28.55	1084536	237394	27.40	297472	19.63	115051	68.10
Total	16799		8034072	100	4088456	100	3945616	866250	100	1515433	100	168954	100

* Pop.: Population

Source: Primary Census Abstract (PCA), 2011, GOI. Census of India 2011.

The Per capita income is an important indicator to measure the standard of living of the people. As per the economic survey 2013-14 it has been observed that the per capita real Net State Domestic Product (NSDP) is increasing from 2004-2005 to 2013-2014 at 2004-05 prices. The per capita income of Odisha, estimated in 2013-14 is Rs 25,891 (Odisha Economic Survey, 2013-14). It is also observed that Khorda has the highest per capita income and Kendrapara has the lowest per capita income.

Coastal districts of Odisha experienced severe cyclones followed by heavy floods which adversely affected the agricultural sector and income from agriculture as well as share of Gross State Domestic product, which is declining over the years. As per the six selected districts of Odisha, Bhadrak contributes the lowest share (2.33%) and Khorda has the highest share (7.52%) in GSDP of Odisha (Economic Survey 2013-14). The industry and service sector has imaged as main driver of economic growth in Odisha.

Finally, regarding consumption expenditure, within the staple food, it has been observed that the consumption of rice is declining from 1993 to 2008 in both rural (15.2 Kg to 13.13 Kg) and urban areas (11.3Kg to 10.3 kg) whereas consumption of wheat has increased marginally. In case of cereal consumption it has been seen that the per capita consumption of rural Odisha was 13.4 Kg whereas in urban areas it was 11.4 Kg (Economic Survey 2013-14)

3 Methodology

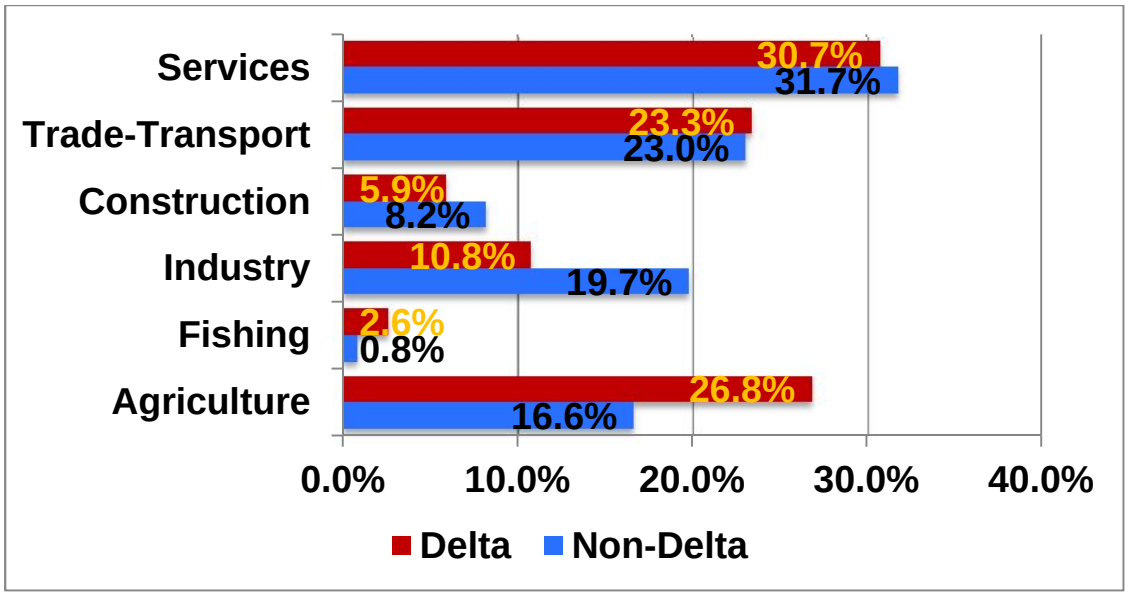
As described in detail in the Appendix 4, we place the focus on the insights for regionalization and construction of tables for the study of Deltaic areas, under the DECCMA. In particular, we firstly describe the general approach taken for all deltas, which consists in gathering socioeconomic and biophysical 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 Mahanadi 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

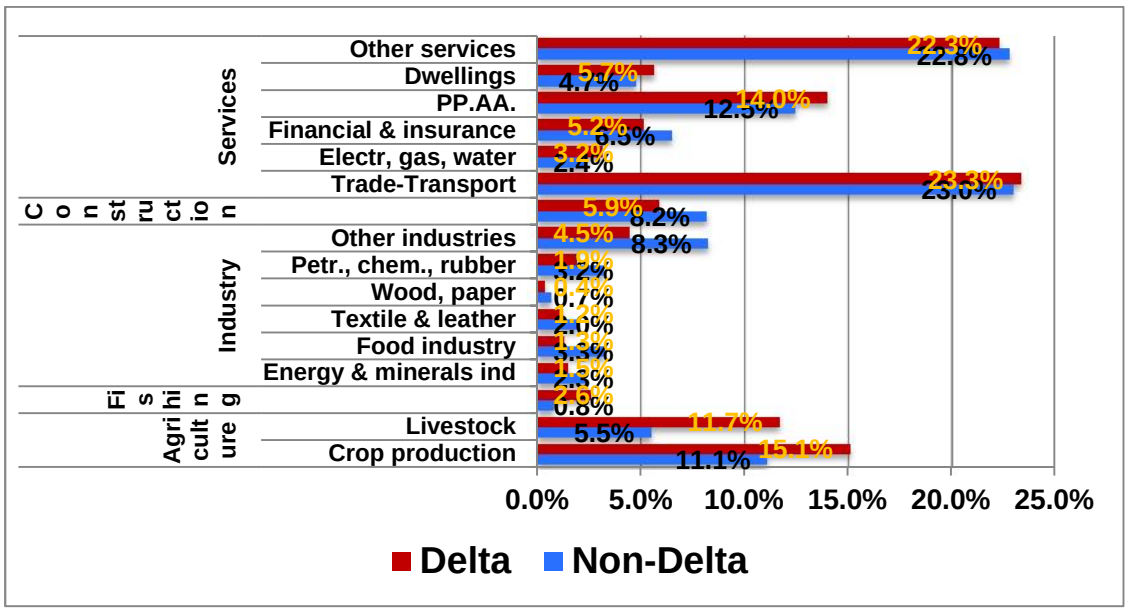
Following the methods of Appendix 4, Figure 3 and Figure 4 show the shares of value added (VA) of the main, respectively, 6 and 16 categories of sectors (from the aggregation of the 57 of GTAP 9).

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.



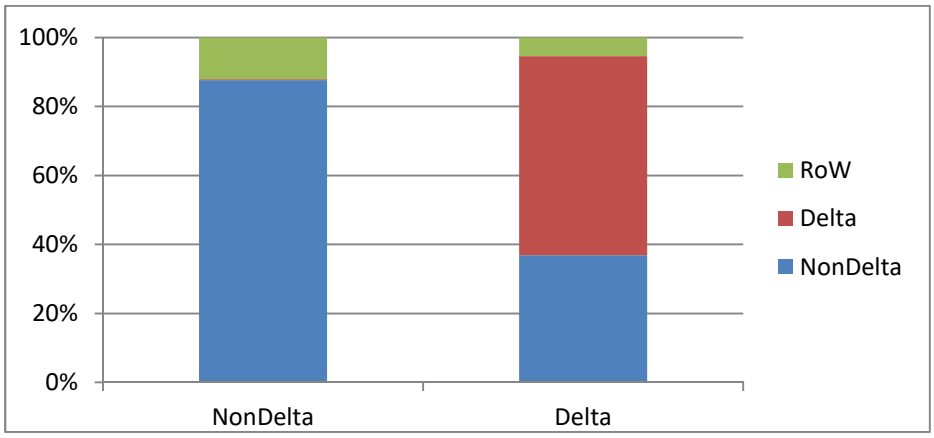
Source: Own elaboration from the computation of VA in the input-output table of the Delta and Rest of the country.

Figures 3 and 4 show the outstanding strong importance of the agriculture sector, notably the crop production sectors, which are relatively much bigger than in the rest of the country (15.1%

of the value added vs. 11.1%), livestock (11.7% of the value added vs. 5.5%) and fishing (2.6% of the value added vs. 0.8%). As a consequence of this huge size, the relative size in value added of any other activity results smaller in the delta than in the rest of the country (non-delta). In any case, 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 important in the delta (slightly higher than in the rest of the country), the same than the employment in Public administrations and Dwellings. On the other hand, the employment in most other services, financial & insurance and in some other industries, is clearly higher in the rest of the country than in the delta. These results indicate the relative backwardness of these delta.

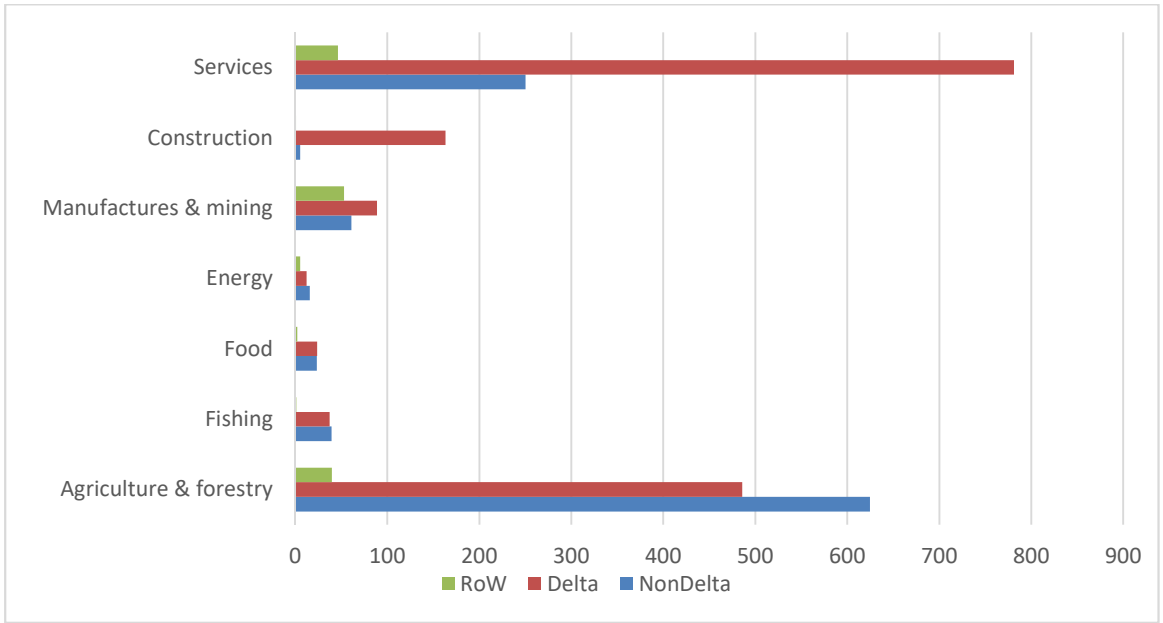
Labour and gender embodiments

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.

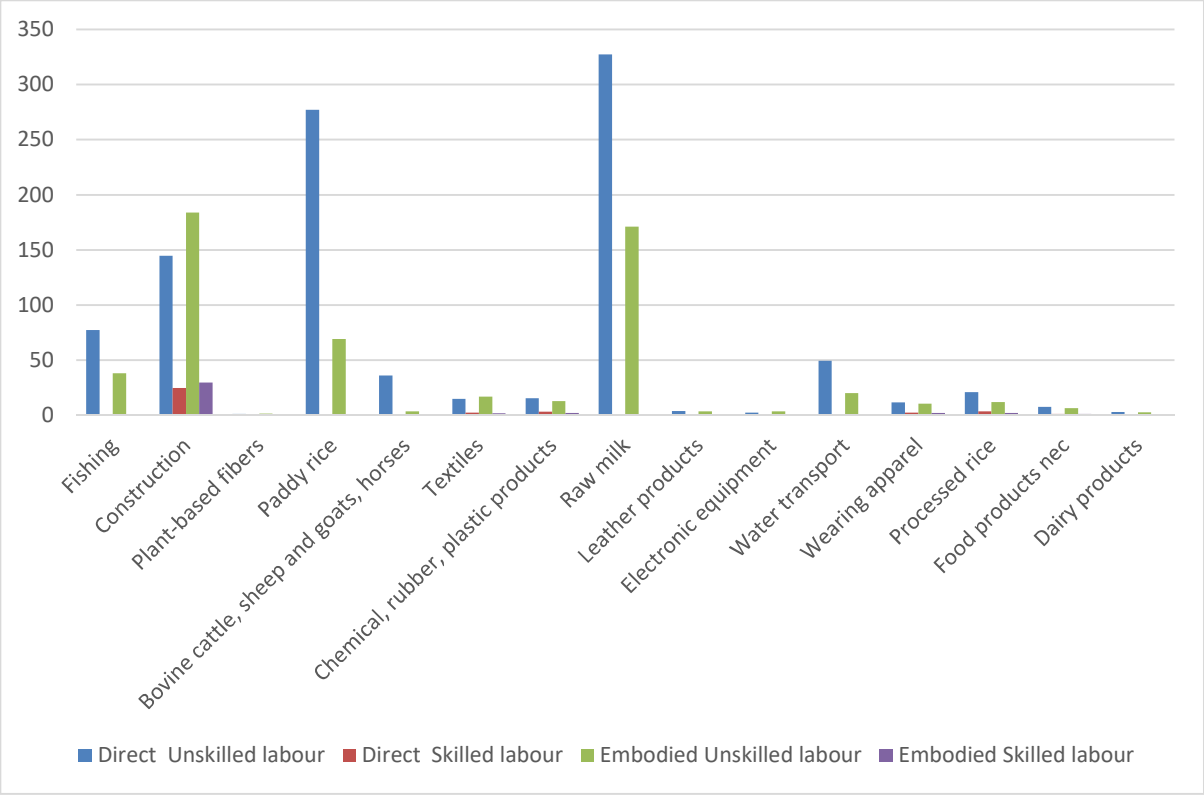
Figure 5b. Employment of the delta by demanding region and sector



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 1,608 thousand (1,608K) 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 (2,488K people) has an important proportion (around 35%) that is originated to satisfy the final demand of the non-delta, while a much smaller proportion (less 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 (2,146K people, around 50%), notably in Services (909K people), Agriculture & Forestry (564K people), and Manufactures & mining (390K people). In the case of Services, an important number of workers (501Kpeople) satisfy the final demand in the Rest of the World. Manufactures & mining (464Kpeople) satisfy the final demand in the non-Delta, while Fishing (only 145K people, dominate employment to satisfy the final demand of the delta itself of 38K people) and Energy satisfy the final demand of the delta itself of 20K people.

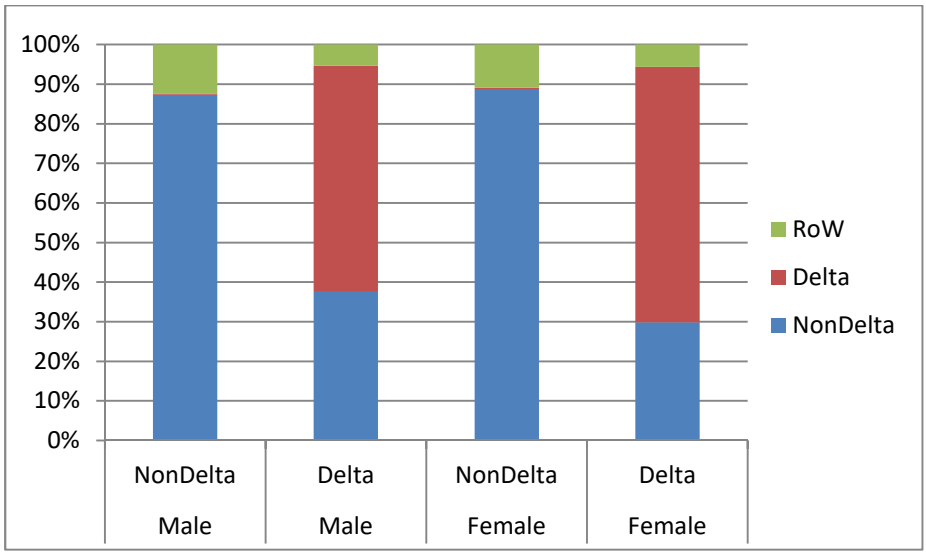
Figure 6. Direct and embodied labour of the delta by sector



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

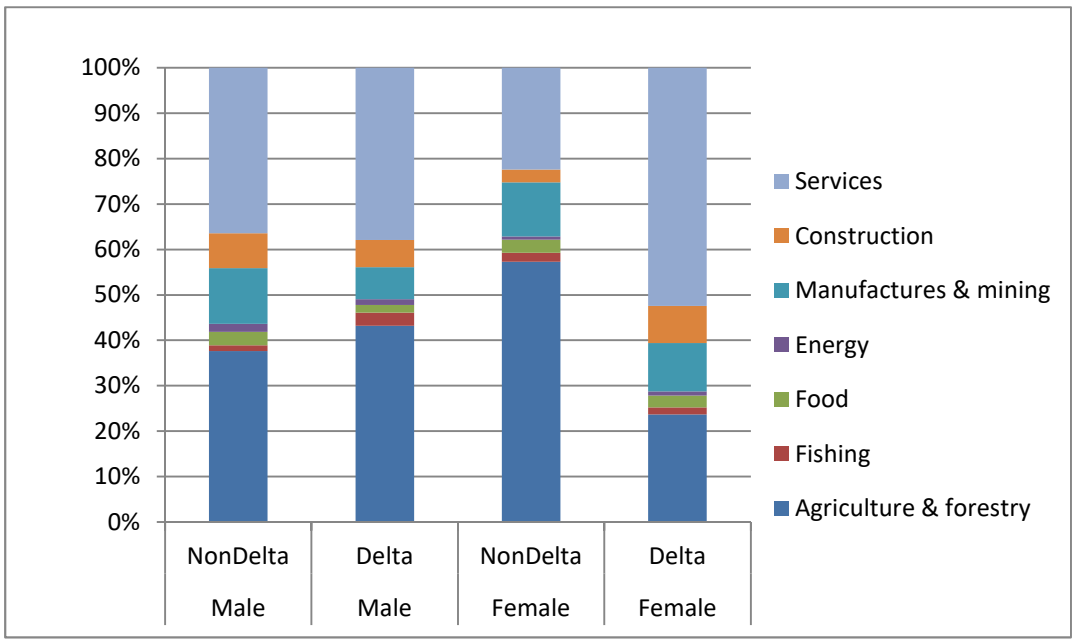
Figure 6 extends the insights obtained in Figure 5, with a sectoral and skill type (according to GTAP classification) detail. In particular, we may observe how is particularly relevant the embodied (directly and indirectly) employment in construction, mostly unskilled, on the raw milk, paddy rice and fishing sectors.

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 7b extend 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 less[1] 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

[1] Contrary to what occurs in the IBD (Sundarbans, India and GBM delta).

the delta mostly in the services, manufactures and fishing, and also (probably surprisingly) in the construction sectors, while being relatively less important in agriculture, energy.

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

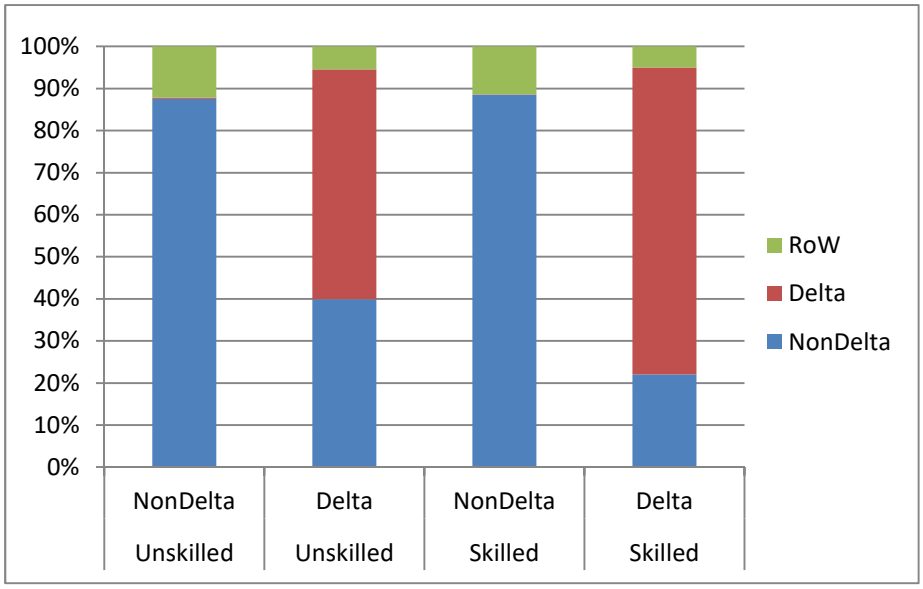
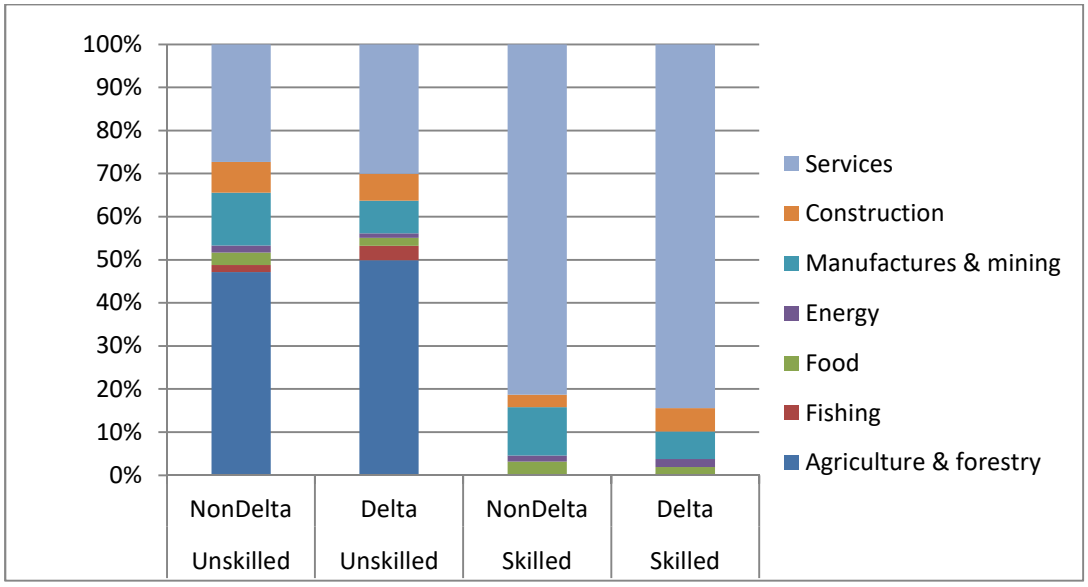


Figure 8b. Embodied labour by sector and skill type (GTAP classifications)



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 the skilled work satisfies directly and indirectly more 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 of skilled work in the delta embodied in the services, while being relatively less important in agriculture, fishing and the construction sectors. In the non-delta, the construction sector has more share of employment (especially unskilled) and the same for

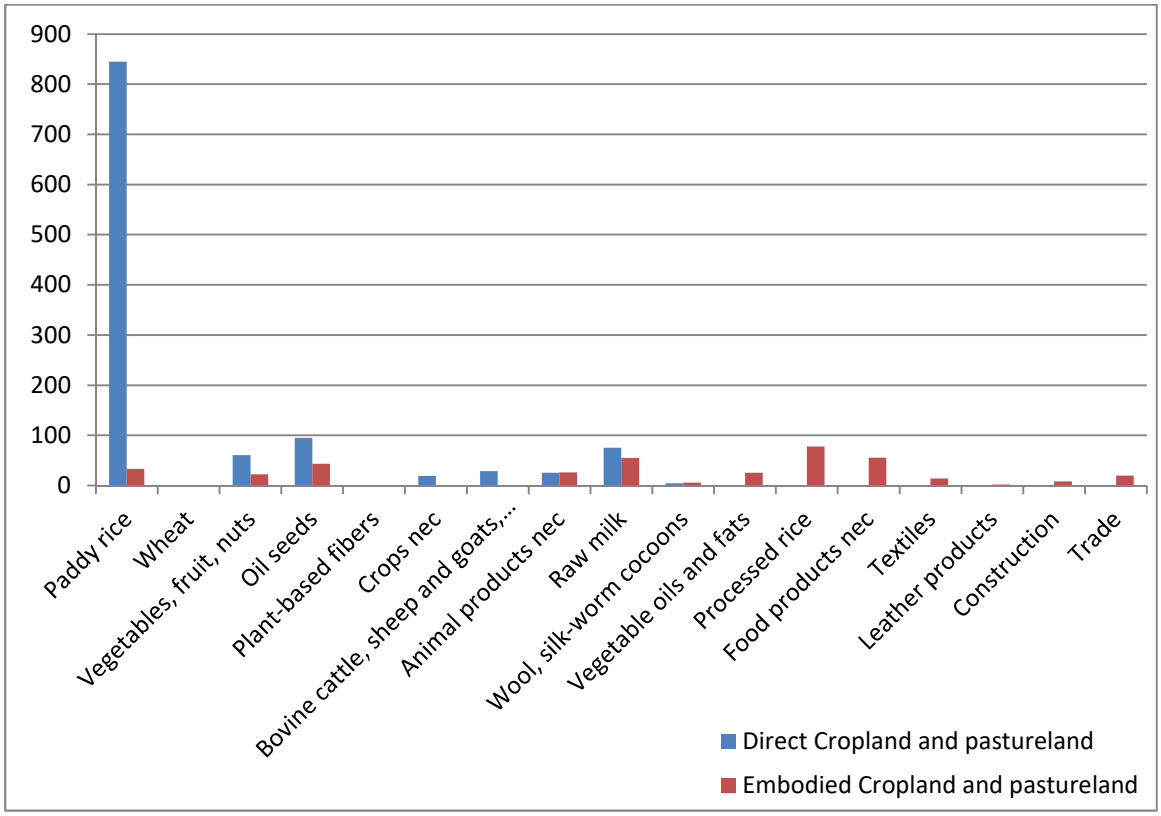
manufacturing & mining, than in the delta, while less in agriculture, which is the main pool of labour of unskilled work.

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 (close to a million 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 processed rice, oilseeds, raw milk and trade is non-trivial, mostly occurring to satisfy the (exports) final demand of the non-delta (also partly the RW).

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 summarizes the direct uses (of resources) or impacts (CO_2 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 agricultural land, embodied in goods and services

sold to other regions (higher than in imports), but net importer of employment, energy and CO2 emissions.

Table 2. Summary of import, export and footprints

	Direct in production	Embodied exports	Embodied imports	Net trade (E-M)	Footprint
Delta. Employment (1000 people)	2,760	1,167	1,745	-578	3,338
Delta. Land (1000 hectares)	1,518	967	627	340	1,178
Delta. Energy (Mtoe)	0.4	0.2	0.3	-0.2	0.6
Delta. CO2(Mt CO2)	2.3	1.2	2.2	-1.0	3.3
Non-Delta. Employment (1000 people)	454,135	56,086	55,965	121	454,014
Non-Delta. Land (1000 hectares)	219,306	24,485	24,443	42	219,264
Non-Delta. Energy (Mtoe)	260	61	60	0	260
Non-Delta. CO2 (Mt CO2)	1,311	230	229	1	1,310

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

Table 3 summarizes the embodied exports and imports between the delta area and the Rest of the country. The delta results net importer of most of the variables considered here: employment, energy and 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)	2,760	1,019	1,286	-267
Delta. Land (1000 hectares)	1,518	886	881	5
Delta. Energy (Mtoe)	0	0.1	0.7	-0.6
Delta. CO2(Mt CO2)	2	0.9	3.9	-3.0
Non-Delta. Employment (1000 people)	454,135	1,286	1,019	267
Non-Delta. Land (1000 hectares)	219,306	881	886	-5
Non-Delta. Energy (Mtoe)	260	1	0	1
Non-Delta. CO2 (Mt CO2)	1,311	4	1	3

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 show the strong importance of the agriculture sector, notably the crop production sectors, which are relatively much bigger than in the rest of the country (15.1% of the value added vs. 11.1%), livestock (11.7% of the value added vs. 5.5%) and fishing (2.6% of the value added vs. 0.8%). As a consequence of this huge size, the relative size in value added of any other activity results smaller in the delta than in the rest of the country (non-delta) this implies the prevalence of relative backwardness of this delta. In any case, the trade and transport activities -which quite often go unnoticed when highlighting important sectors of the deltas, such as small business trade, etc.- were revealed relatively important in the delta (slightly higher than in the rest of the country), the same than the employment in Public administrations and Dwellings. On the other hand, the employment in most other services, financial & insurance and in some other industries, is clearly higher in the rest of the country than in the delta. The work of females satisfies directly and indirectly less the final demand abroad (both in the non-delta and in the Rest of the World than the work of male). Like IBD women in this delta are not engaged in activities which generate either outputs or intermediate inputs that can significantly catered to external demand. The embodied work of women in the delta is most present in services, manufactures and fishing, and also in the construction sector, where women in large number act as helping hands in carrying labour intensive raw materials like cements bricks etc. while being relatively less important in agriculture, energy. The main skilled work in the delta is embodied in the services, while being relatively less important in agriculture, fishing and the construction sectors. In the non-delta, the construction and manufacturing & mining sectors have more share of employment than in the delta, while less in agriculture, which is the main pool of labour of unskilled work.

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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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: Puri, BHadrak, Kendrapara, Jagatsingpur, Khordha

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.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.) .

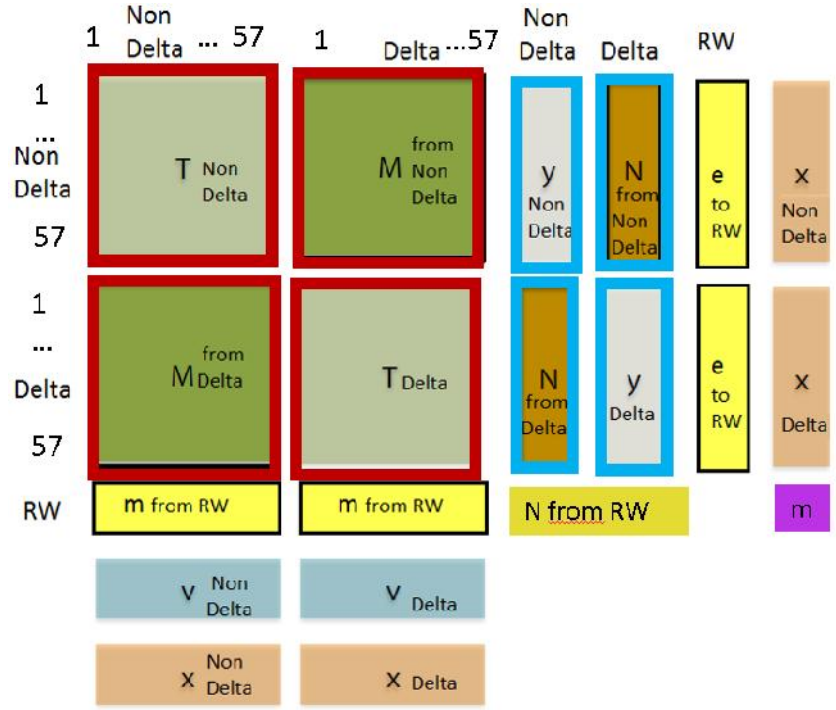
Developing regional tables and extensions of specific Deltaic areas, not matching the economic or political boundaries poses additional challenges, so we focus on.

- 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 **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: $\mathbf{x=Ax+y \leftrightarrow x=(I-A)^{-1}y}$ (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,**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:

ω=r'(I-A)$^{-1}$ (2)

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

r'x=r'(I-A)$^{-1}$y=ù'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[2], 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 main information that allows doing the regionalization are the (PCA, 2011), (GoO, 2013), (GoO, 2016). With these tables, for the Mahanadi 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

[2]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).

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.

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 the reports on land use of “Different “District Statistical Handbook of year 2011 and Orissa Economic Survey of different years, from the Directorate of Economics and Statistics (GoO) and others: (Banerjee; GoO, 2015; Manmohan; PCA-Odisha, (2001 & 2011); Srikanta; Vinod and Bhattacharya). Also previous background was obtained from (GoO, 1986), (Ray, 1988), (Ray and Mohanti, 1989).