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TECHNICAL PAPER - 2
NOVEMBER 2023

Developing an Environmentally-extended Social Accounting Matrix for India 2019-20

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Recommended citation:
Chadha, R., Sivamani, G. and Verma, R. (2023). *Developing an Environmentally-extended Social Accounting Matrix for India 2019-20* (Technical Paper 2). New Delhi: Centre for Social and Economic Progress.

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Developing an Environmentally-extended Social Accounting Matrix for India 2019-20

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List of Abbreviations

ACE	Annual Consumption Expenditure
CGE	Computable General Equilibrium Model
CH4	Methane
CIS	Change in Stock
CO	Carbon Monoxide
CO2	Carbon Di-Oxide
CSEP	Centre for Social and Economic Progress
EIOT	Energy Input-Output Table
ESAM	Environmentally extended Social Accounting Matrix
FOP	Factor of Production
GCF	Gross Capital Formation
GDP	Gross Domestic Product
GFCE	Government Final Consumption Expenditure
GFCF	Gross Fixed Capital Formation
GHGs	Greenhouse gases
GVA	Gross Value Added
HCE	Household Consumption Expenditure
IOT	Input-Output Table
KLEMS	Capital, Labour, Energy, Materials and Service
MoC	Ministry of Commerce and Industry
MoSPI	Ministry of Statistics and Programme Implementation
MPCE	Monthly Per-Capita Expenditure
N	Standard Output Multipliers
N'	Emissions Output Multipliers
NAS	National Account Statistics
NEC	Not Elsewhere Classified
NFI	Net Factor Income
NH3	Ammonia
NIC	National Industrial Classification
NIT	Net Indirect Taxes
NOx	Nitrogen Oxides
NSO	National Statistical Office
NSSO	National Sample Survey Office
OBC	Other Backward Caste
OSG	Other Social Groups
PFCE	Private Final Consumption Expenditure
PLFS	Periodic Labour Force Survey
PM	Particulate Matter
RBI	Reserve Bank of India
RES	Renewable Energy Sources
ROW	Rest of the World
SAM	Social Accounting Matrix
SC	Scheduled Caste
SEEA	System of Environmental-Economic Accounting
SOx	Sulphur Oxides
ST	Scheduled Tribe
SUT	Supply and Use Tables
VA	Value Added
VOC	Volatile Organic Compounds

Abstract

This study provides the methods and materials for constructing a Social Accounting Matrix (SAM) 2019-20 for India. SAMs are a valuable tool for understanding the effects of various fiscal policies on equity and the economy. They serve as a comprehensive economic database, detailing transactions among economic agents like producers, households, and the government. SAMs are essential inputs for enhancing economic analysis through Computable General Equilibrium (CGE) models and calculating various economic multipliers, making them valuable tools for examining the consequences of government policies on different economic variables.

The standard SAM framework has been expanded with an Environmentally-extended SAM (ESAM) that integrates data on emissions, thus enabling us to assess climate policy interventions. The ESAM includes three pollution types: air emissions, wastewater generation, and land degradation.

The ESAM constructed in this paper includes 45 production sectors, 318 categories of labour, 80 household categories, and 3 environmental pollution categories. The labour factor of production is further disaggregated by region, social group, occupation, education, and gender. Households are disaggregated based on regions, social groups, and annual consumption expenditures. The ESAM is used to compute output, labour income, and employment multipliers, while the environmental extension provides emissions multipliers.

This study tackles the existing research and data gaps regarding pollution generation by incorporating sector-specific data from India's greenhouse gas inventory. It attempts to introduce a novel approach to categorise labour in this ESAM, which can be used to investigate the questions of income inequality across regions, social groups, educational attainment, and gender, amongst others.

The CSEP ESAM for India 2019-20 database can be downloaded from the CSEP website

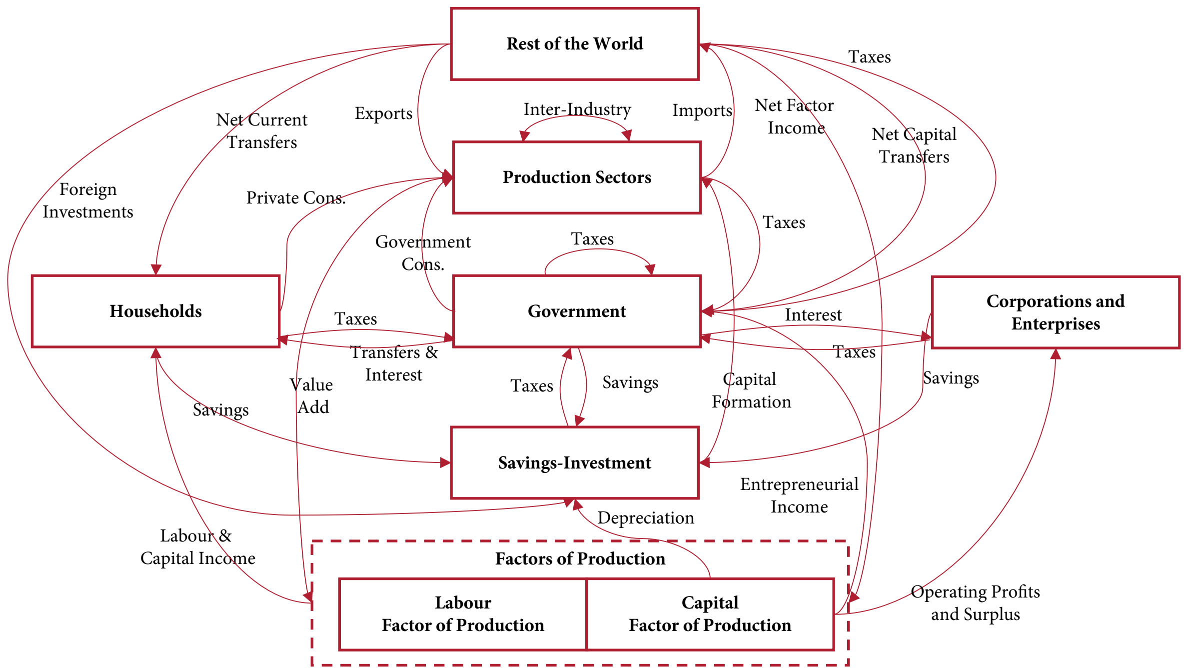
1. Introduction

As concerns grow about the effects of greenhouse gas emissions on climate change, the world is becoming increasingly conscious of the need to adopt greener production and consumption patterns to mitigate the impacts of global warming. Given the complex nature of these effects, examining them through a unified dataset that can quantify the interrelationships between various economic and environmental sectors is essential. Although challenging, quantification can help analyse the intertwining relations and thus aid in analysing the impacts of different mitigation policies on the economy. This analysis empowers policymakers to make informed decisions by enabling the quantification of ex-ante effects.

While sector-based studies are essential to understand the respective sectoral interrelationships vis-à-vis climate change, the multi-sectoral approach is a powerful tool to analyse the cross-sector implications of climate change's causes, effects, and the accompanying social distribution issues. The Social Accounting Matrix (SAM) is one such unified dataset providing the inter-sectoral linkages between production sectors, factors of production, households, government, and other institutions. The United Nations published the System of Environmental-Economic Accounting (SEEA) in 2014, which was the first international standard for environmental-economic statistics (United Nations, 2014). Many countries have adopted this standard to ensure consistent environmental and economic statistical information, enabling them to understand and analyse policy-relevant questions. SAMs have also been enhanced with energy and emissions balance information to design Environmentally Extended SAMs (ESAMs) (Banerjee et al., 2019). Furthermore, ESAMs provide valuable datasets for analysis, including the data needed for computable general equilibrium (CGE) models.

A SAM is an economy-wide framework which depicts the interactions of various economic activities between the economic agents such as producers, factors of production, households, and government. It represents an extension of the Input-Output table (IOT), incorporating social accounts through disaggregation of the factors of production (labour and capital) and the household sectors to complete the circular flow of income. The row entries represent the receipts, and the column entries depict expenditures. The SAM provides details of the distribution of the factor incomes from the production activities to the factors of production and, further, to the households. Households spend this income on the goods produced from the production activities. In addition to the IOT

Figure 1 Circular Flow in the Economy of CSEP-ESAM



Source: Authors' Elaboration.[1]

[1] Arrows point in the direction of monetary flows.

accounts, the SAM includes institutional accounts' incomes and expenditures, tax revenue generation and usage, and foreign income and spending, completing the flow of income in the economy. The environmentally extended social accounting matrix (ESAM) captures reciprocal interactions between the economic system and the environment. It documents the usage and damage of environmental resources caused by economic activities.

This paper describes the methods and data used to construct a comprehensive ESAM for India 2019-20. These details provide a technical backdrop to the construction of the CSEP-ESAM. This ESAM will delve into the inter-sectoral linkages between the productive sectors, factors of production, government, institutions, savings, and the rest of the world (the monetary flows between these economic agents have been depicted in Figure 1). Furthermore, it will also include the interlinkages of these agents with three types of environmental sectors: air, water, and land. It will also depict the pollution generated from burning natural resources, such as coal and petroleum products. This would aid researchers and policymakers in insightful analysis and effective decision-making. Some ensuing analytical findings are elaborated in Section 5 through the computation of simple SAM multipliers, which can help provide some insights into the impacts of policies on distribution, the economy, and emissions. The SAM is also required for the more advanced computable general equilibrium (CGE) models.

This paper has been divided into six sections. The second section details the findings from the existing literature on SAMs/ESAMs. It attempts to review these matrices to understand the classifications of the factors of production, households, and environment. Section three builds on this review and breaks down the structure of the CSEP-ESAM developed in this study. Section four outlines the data and methods utilised to construct the ESAM for India-2019-20, which incorporates updating the CSEP Input-Output Table-2015-16 and constructing the CSEP Input-Output Table 2019-20. After that, we explain the extension of this table to the ESAM by adding data on value-added households and other institutions. Section five details the methods and results of the multiplier analyses to compute the output, employment and emissions multipliers and their linkages. Section six provides concluding remarks.

2. Literature on Existing ESAMs

Various SAM and ESAM matrices vary in their structures when disaggregating factors of production and households. This study has examined 21 matrices comprising 15 SAMs and 6 ESAMs (Appendix A). These 21 matrices were constructed for ten countries, of which 12 refer to India, including three ESAMs. The remaining nine refer to one each for Brazil, Chile, China, Guatemala, Indonesia, Iraq, Malaysia, Saudi Arabia, and South Africa. 12 of these 21 accounting matrices had a decomposition of their factors of production, with most categorising labour according to their skills (either unskilled, semi-skilled, and skilled) or their occupational characteristics (such as formal and informal workers). Gallardo & Mardones (2013) and Debowicz (2016) combined the skill sets of labourers with their gender to represent the disparity of payments across gender and skills. Some matrices also used region (rural and urban) to distinguish the rural-urban divide in payments to labourers. The SAM by Althumairi (2021) classified the labourers in Saudi Arabia based on their country of origin, i.e., Saudi and non-Saudi workers. The capital has been classified as oil and non-oil capital due to the specific nature of the Saudi economy, wherein a significant contribution to GDP is attributed to oil extraction. Kavese and Phiri (2020) use a three-fold categorisation of age, education, and region to explain the difference in factor incomes based on these three categories for South Africa. Hartono and Resosudarmo (2008) had 16 different labour classes comprising the region, type of worker (formal/informal) and occupation. The division of labour categories provides a better understanding of the social characteristics of a country and the differences in the factor incomes.

Five of the 12 SAMs for India reviewed have used detailed classification for labourers. Three of them have classified the workers as per their skill sets. The most distinct of these is by Pal and Bandarlage (2017), who categorise the workers based on their social groups (ST, SC, OBC and Others), education, gender, and region, which results in a total of 48 categories. This level of detailing is relevant in the Indian context as the issues relating to the social groups are specific to the country, and having this classification in a SAM will provide a better understanding of the distribution of the factor incomes across social classes. It will further aid in comprehending the impact of any government intervention on various social classes.

For instance, their study analyses the impacts on income distribution due to an exogenous increase in the final demand of one of the crops, say paddy, providing impetus to the labourers' and households' incomes belonging to various social strata. Through this SAM, they study the level of inequality in India and the sectors which could be targeted to reduce the unequal income distribution.

The categorisation of households is another essential attribute of a SAM, as it aids in understanding household expenditure and studying the impact of government policies on the economy. Three studies classified the households by income (Carneiro & Junior, 2018; Gallardo & Mardones, 2013; Althumairi, 2021), and six used the consumption expenditure categories combined with their regions. Debowicz (2016) uses a unique classification separately identifying female-headed households in Iraq, further classifying them by region and per-capita expenditure. Such a classification can answer some of the gender-related growth issues. Social inequities vary by country. For example, racial discrimination is more prevalent in some countries than others. Two SAMs utilise the racial aspects of their respective countries, combining this with income or region. The study by Kavese and Phiri (2020) disaggregates households by race (African, White, Coloured, and Indian) and 12 income categories for South Africa. Harun et al. (2012) have eight categories comprising the rural-urban distribution of four races in Malaysia: Malay, Chinese, Indian, and Others. Pal and Bandarlage (2017) use social groups (ST, SC, OBC, and others) as their basis of categorisation, which they combine with the per-capita expenditure deciles to represent the spending patterns of the households classified across the social groups.

The six reviewed ESAMs extend the standard SAM with data on environmental pollution in the respective countries. Air pollution has been represented in five of these ESAMs by providing information on the GHGs such as CO_2, N_2O and CH_4. Gallardo and Mardones (2013) is the only reviewed study that details seven different air pollution parameters.[2] There are six different kinds of GHGs represented in their accounting matrix, and further, they also give information on pollution caused by particulate material PM_{10}. Banerjee et al. (2019) follow the structural framework of the SEEA and, thus, provide eight environmental classifications, viz. water, forestry, fishing, mining resources, energy, emissions, waste, and land use in Guatemala. This is the most detailed ESAM which appears to be available in the literature, and the possible reason for this is the availability of SEEA publications for Guatemala. While this ESAM does not include any measure of water and land pollution, it just maps the flow of natural resources across various economic activities. Two ESAMs reviewed for India, viz. Pal et al. (2015) and Verma (2021) provide information on the environment-economic interlinkages of 2006-07 and 2007-08, respectively. While the former study includes the pollution from the air, the latter reference encompasses all three types of pollution: air, water, and land. Verma (2021) uses wastewater from industries, agriculture, and households to indicate water pollution. Such a classification is similar to the study by Xie (2000), which also uses this indicator. None of the reviewed ESAMs provide detailed sectoral-level data on the depletion of natural resources and pollution emitted from coal, petroleum products, and other combustible materials.

These studies underscore the importance of having a detailed classification of factors of production and households, as these categories help better represent the economy and further aid in understanding the varying impacts of governmental policies on different social structures.

3. Structure of CSEP-ESAM

The structure of the CSEP-ESAM for India 2019-20 is provided in Appendix B. Each sector is represented in one of the rows and columns, making the ESAM a square matrix. The first ten rows and columns represent the SAM structure; the subsequent three rows show the environmental extensions of this ESAM. The first ten rows show supply/income; the corresponding columns show demand/expenditure. While each row and column in the ESAM represents individual sectors, the structure shown in Appendix B represents the broad economic agents, which may be further disaggregated. For instance, the interaction between the first row and first column (1,1) represents the *supply* of goods and services by the 45 industries fulfilling the *demand* for goods/services generated by these 45 industries in the columns (i.e., this cell represents a 45x45 matrix). Likewise, the cell

[2] Seven air pollutants considered in this study are: respirable particulate material (PM10), carbon monoxide (CO), carbon dioxide (CO2), nitrogen oxides (NOx), volatile organic compounds (COV), sulphur oxides (SOx), and ammonia (NH3). Three categories of water pollutants: oils and fats, chlorides, and sulphates.

in the second row and first column (2,1) represents the wages received by the labour factors of production from the 45 industries shown in the columns.[3] For the production sectors, this interaction can be understood as an expenditure. Thus, a SAM/ESAM can be understood as a single-entry accounting instead of conventional double-entry bookkeeping, as the same cell represents receipts and payments.

A comprehensive categorisation of the factors of production and household classes is required for any detailed analysis of the effect of an exogenous economic shock using a SAM/ESAM. The CSEP-ESAM for India accounts for 45 production sectors and disaggregates labour into 318 categories and households into 80 categories.[4] We use five indicators for classifying labour categories: region, social class, occupation of the head of the family, education, and gender. Some studies highlighting these indicators' importance in the Indian context are mentioned below.

The rural-urban (region) divide in the factor payments is considered an important factor by Hnatkovska and Lahiri, 2013, Kundu and Pandey, 2020 and Ghosh et al., 2019. The social group of an individual worker, namely scheduled tribe (ST), scheduled caste (SC), other backward classes (OBC) and other social groups (OSG), plays a dominant role in determining the type of employment, which further affects the factor income of that individual (Gupta & Kothe, 2021; Singhari & Madheswaran, 2016; Das & Datta, 2007). The occupational category of the head of the family is also vital for the level of education that children will receive, which then affects the earnings of labourers (Kundu & Mohanan, 2009). The relationship between gender and factor payments is another aspect worth considering (Ara, 2021; Lama and Majumder, 2018; Deshpande et al., 2015).

We classify households using three indicators: region, social groups, and decile classes of household annual consumption expenditure (ACE). Inequality analyses in India are typically conducted using the Monthly Per-Capita Expenditure (MPCE) data as the detailed data for the households/individual income is unavailable. Therefore, these deciles will be an essential indicator for examining the changes in the levels of inequality due to an exogenous policy change. This categorisation yielded a total of 80 classes.

This ESAM represents three types of pollution: air, water, and land degradation. Greenhouse gas (GHG) emissions have been used as the parameter for air pollution, wastewater generation represents the extent of water pollution, and land degradation has been estimated using industrial and mining wastelands. Air and water pollution are described in the rows and columns as the absorption and generation of damaging substances (pollutants). The rows show the absorption of these pollutants, such as wastewater treatment or carbon sequestration in forests, while the columns depict the pollution generated by various industries and households. The rows and columns of the depletable/degraded natural resources represent land degradation, wherein the rows represent the extent of depletion/degradation, and the columns represent the renewal of these resources. Natural resources are inputs for the production processes of various industries, and the inputs supplied to various sectors are described in the rows of an ESAM. The final rows and columns relate to the environmental theme, indicating GHG emissions and absorptions.

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[3] The brackets mentioned in the rows and columns in Table 2 give the number of different entries within those rows and columns. For example, 318 mentioned in the row and column of the Labour-FOP implies 318 different categories of labour. There are 318 different rows and 318 separate columns of labourers in the ESAM.

[4] For rural area: Rural (1) x Social Group (4) x Occupational Category (6) x Education (4) x Gender (2) = 192. For Urban area- Urban (1) x Social Group (4) x Occupational Category (4) x Education (4) x Gender (2) = 128, a total of 320 categories, but of this 320, three categories did not have any data on the labour income because these permutations do not exist in India. Hence, the total number of categories for labour are 318.

4. Data and Methods for the Construction of ESAM 2019-20

This section highlights the data and methods used to construct the ESAM 2019-20. The details provide a technical backdrop to its construction. The ensuing analytical findings for the economy are elaborated in Section 5.

The primary data sources include the CSEP IOT 2015-16 (based on official SUTs for the same year), National Accounts Statistics, household and labour force surveys, and the Reserve Bank of India. The SAM totals are balanced with national accounts data to ensure that key macroeconomic figures are consistent.

The interaction between the production accounts of the ESAM (1,1) is, in effect, an input-output table (IOT) representing the economy's inter-industry flows. These are the monetary flows between the production sectors of an economy, such as machinery manufacturers consuming steel, steel plants consuming iron ore, and iron ore mines purchasing mining machinery. When constructing the CSEP-ESAM, the most recently published input-output table was the CSEP Input-Output Transactions Table 2015-16 (Chadha et al., 2020). This is a 131-sector IOT, providing details on industry-to-industry flows, the sectoral gross value added (GVA), net indirect taxes (taxes minus subsidies, NIT), private final consumption expenditure (PFCE), government final consumption expenditure (GFCE), gross fixed capital formation (GFCF), net acquisitions of valuables, change in stock (CIS), exports, and imports. This table was constructed using the Supply and Use Table (SUT) 2015-16 published by the Ministry of Statistics and Programme Implementation (MoSPI), Government of India, the most recent SUT available at the time of construction. The most recent IOT published by the Government of India was for 2007-08 (Ministry of Statistics and Programme Implementation, 2012); the CSEP IOT 2015-16 followed a similar methodology and sectoral classification, except for an additional grain milling sector.

More recently, the SUTs of 2016-17 to 2019-20 have also been published. The IOT used in the CSEP-ESAM is an aggregated IOT 2015-16 that has been updated for 2019-20 using the RAS[5] methodology. The RAS method is a mathematical estimation technique used to construct input-output tables for a given year using an IOT from a previous year (Gretton & Cotterell, 1979). Ideally, an IOT 2019-20 constructed from corresponding SUTs should be used to build the CSEP-ESAM. However, the RAS methodology was utilised to estimate the IOT 2019-20 due to the unavailability of this year's SUT during the construction of the CSEP-ESAM.

4.1 Updating the CSEP Input-Output Table 2015-16

The first step in estimating IOT 2019-20 is to convert the CSEP-IOT 2015-16 into the required structure. The CSEP-ESAM contains 45 production accounts, which were aggregated (and in some cases, specific sectors were disaggregated) from the 131-sector CSEP-IOT. These 45 sectors were chosen for their importance to the economy and relatively high energy uses. This section details how the 2015-16 IOT was converted into a 45-sector IOT for the same year. The mapping of the 131 to 45 sectors is given in Appendix C. The mapping, aggregation, and disaggregation of sectors of the CSEP-IOT to CSEP-ESAM broadly follow the steps taken by Chadha & Sivamani (2022), which provides the methodology for constructing a 34-sector Hybrid Energy IOT (EIOT). However, the CSEP-ESAM aggregates and disaggregates specific sectors differently, as it comprises 45 production sectors based on the methodology and the rationale outlined in the subsequent sections.

Aggregation of Sectors

The study aggregated certain sectors from the 131-sector 2015-16 IOT to create the CSEP-ESAM 2019-20, focusing on specific energy-intensive sectors. The following sectors were aggregated differently compared to the Hybrid EIOT by Chadha and Sivamani (2022).

- The Paddy sector was separated from the aggregate Agriculture sector due to its significant environmental footprint.
- The Livestock sector was separated from the aggregate Agriculture sector. It includes Milk & Milk Products, Poultry & Eggs, Other Livestock Products, and Animal Services.

[5] The origin of the acronym RAS is unclear. Some sources propose that it may refer to pre- and post-multiplying the technical coefficient matrix, A, with R and S respectively to reach the desired final matrix.

- The CSEP IOT 2015-16 contains data for eight mining sectors. This SAM disaggregates these sectors, except for combining mica with other non-metallic mineral products. Mica mining is a relatively small sector in the Indian economy. Hence, mica was aggregated with the Other Non-Metallic Mineral Products sector.
- Fertiliser was kept separate from the Chemicals sector aggregation as it is energy intensive.
- The Rubber Products and Plastic Products sectors were aggregated as a new sector, Rubber and Plastic Products, instead of aggregating with the Industries not elsewhere classified (NEC) sector.

Disaggregation of Sectors

Similar to the aggregation, the disaggregation of specific energy-intensive sectors closely follows the approach presented in the EIOT by Chadha and Sivamani (2022). The sectors were disaggregated as follows:

- Disaggregating the Non-Ferrous Basic Metals sector into Aluminium and Other Non-Ferrous Basic Metals sectors. This was done due to the high energy intensity of the Aluminium sector and its importance to the economy.
- The Electricity sector was disaggregated into five sectors: Coal Electricity, Other Thermal Electricity (gas- and diesel-based generation), Large Hydroelectricity, Nuclear Electricity, and Renewable Energy Sources (RES) Electricity. This study extends the disaggregation of the EIOT by disaggregating the Nuclear and RES Electricity sectors (which were given as one sector). Data for this were obtained from the annual report of the Nuclear Power Corporation of India Limited, which provides information on the inputs of India's nuclear electricity power plants.
- The Biomass sector was disaggregated from the parent sectors of Paddy, Agriculture, Livestock, Forestry & Logging, and Food & Tobacco. Biomass is considered an important sector, as approximately 32% of the country's total primary energy use is derived from biomass, and over 70% of India's population relies on biomass for its heating and cooking energy needs (Ministry of New and Renewable Energy, 2021). The disaggregation of the Biomass sector follows the same methodology as Chadha & Sivamani (2022), which includes using data from the SUTs and the household consumption expenditure survey (NSS 68th round).
- The Petroleum Products sector was divided into Combustible Petroleum Products and Non-Combustible Petroleum Products. This is important for calculating energy and emissions flows, as only Combustible Petroleum Products emit GHGs when burned.

4.2 Constructing CSEP Input-Output Table 2019-20

The next step in utilising the RAS methodology to update the input-output table to 2019-20 was the collection of relevant sectoral macroeconomic data. The data primarily come from the National Account Statistics (NAS) and the Ministry of Commerce (for sectoral exports and imports). Some net indirect taxes (NITs) data were estimated using IOT 2015-16. Table 1 outlines the macroeconomic data structure and sources for IOT 2019-20.

Table 1 Structure and Data Sources of IOT 2019-20

IOT 2019-20	Production Accounts (45)	PFCE	GFCE	GCF	Exports – Imports	Output
Production Accounts (45)	RAS Estimate	NAS	RBI & NAS	NAS	Ministry of Commerce & NAS	NAS
NIT	NAS & IOT 2015-16	NAS & IOT 2015-16	NAS & IOT 2015-16	NAS & IOT 2015-16	NAS & IOT 2015-16	NAS
GVA	NAS	N/A	N/A	N/A	N/A	NAS
Output	NAS	NAS	RBI & NAS	NAS	Ministry of Commerce & NAS	NAS

Source: Authors' Elaboration.

Private Final Consumption Expenditure

NAS provides data on households' PFCE for 2019-20 by commodity. However, NAS only has 34 sectors, while the IOT requires a 45-sector breakdown. NAS data were used for sectoral PFCE, wherever feasible, with disaggregation for specific sectors using CSEP-IOT 2015-16 (refer to Appendix D for the NAS to SAM sector mapping).

Government Final Consumption Expenditure

The Government's Final Consumption Expenditure (GFCE) represents the spending by all government bodies within the country, which includes the central government, state governments, and local bodies. While GFCE is a final demand sector, some government expenditures are represented as an intermediate sector through the public administration and defence sector, which is a part of the commerce and public services sector in CSEP-ESAM.

According to the IOT 2007-08 handbook by MoSPI regarding the construction of the GFCE sector, the compensation of government employees is accounted for in the public administration sector, and GFCE holds no GVA. On the other hand, GFCE pays NITs and not the public administration sector. The IOT 2015-16 allocates expenditures for education & research, medical & health, community services, other services, and public administration and defence to GFCE. A significant part of GFCE is allocated to public administration and defence, which subsequently feeds into other economic sectors within the intermediate industry framework.

While constructing the GFCE sector for 2019-20, it was assumed that the sectoral expenditures proportion remains the same as from IOT 2015-16. The total government expenditure data was sourced from two Reserve Bank of India (RBI) publications: RBI Bulletin 2020 (Reserve Bank of India, 2020) and State Finances 2021-22 (Reserve Bank of India, 2021). The former provides the union government expenditure, and the latter the state government's expenditures. Table 2 compares the total GFCE (i.e., GFCE and public administration expenditure for the IOT) between the IOT and RBI data.

The RBI GFCE value for 2019-20 was used to build the IOT 2019-20. The sectoral expenditure ratios were taken from IOT 2015-16, including the public administration expenditure, and applied to the RBI GFCE value. As per the sectoral mapping, the computed public administration expenditures were aggregated with the aggregated commerce and public services sector.

Table 2 Comparison of Government Final Consumption Expenditure Data (in Rs crore)

	2015-16	2019-20
Input-Output Table	24,10,452	–
Reserve Bank of India	28,91,520	44,46,537

Source: CSEP-IOT and RBI.

Gross Value Added

The National Accounts Statistics provides data on the economy's total and sectoral gross value added (GVA). The NAS data also provides the components of sectoral GVA: production taxes *less* subsidies, consumption of fixed capital, employee compensation, and operating surplus/mixed-income. The aggregate sectoral GVA data were needed to build the IOT 2019-20. The GVA data had to be disaggregated for some sectors utilising suitable ratios from the IOT 2015-16.

Gross Capital Formation

Gross Capital Formation (GCF) or investment refers to a sector's purchase of assets minus their disposal. GCF is the aggregate of the purchases minus sales of three accounts: Gross Fixed Capital Formation (GFCF), Change in Stock (CIS), and Valuables. While the IOT 2015-16 offers a breakup of GCF, the IOT 2019-20, due to the lack of data, only provides the aggregate GCF account. The total GCF in the economy was taken from NAS, and the sectoral split was computed using the division from IOT 2015-16 (as no data was available for sectoral GCF).

Exports and Imports

The Ministry of Commerce and Industry (MoC) trade statistics portal supplied the sectoral export and import data for goods (Ministry of Commerce and Industry, 2022), while the services trade data were sourced from the RBI Balance of Payments report and NAS.

Sectoral export and import data for goods came from the Ministry of Commerce and Industry (MoC) trade statistics portal, while services trade data was from

Table 3 Comparison of Trade Data Between Various Sources (in Rs Lakh)

Year	Source	Sector	Exports	Imports
2015-16	CSEP IOT	Merchandise	13,46,76,486	24,90,29,857
		Services	12,45,06,995	4,87,94,330
		Total	25,91,83,481	29,78,24,187
	RBI	Merchandise	17,43,28,900	25,92,82,000
		Services	10,10,44,600	5,54,61,700
		Total	27,53,73,500	31,47,43,700
	MoC / NAS	Merchandise	17,16,38,440	24,90,30,554
		Services	10,00,18,900	4,56,26,600
		Total	27,28,64,700	29,52,83,572
2007-08	MoSPI IOT	Merchandise	4,91,46,316	10,33,80,978
		Services	4,66,80,021	2,08,65,901
		Total	9,58,26,337	12,42,46,878
	RBI	Merchandise	66,800,800	10,35,67,300
		Services	3,63,00,000	2,06,80,000
		Total	10,31,00,800	12,42,47,300
	MoC	Merchandise	6,55,86,352	10,12,31,170
		Services	N/A	N/A
		Total	N/A	N/A

Sources: Ministry of Commerce and Industry (2022), Reserve Bank of India (2020), MoSPI Ministry of Statistics and Programme Implementation (2012), Chadha et al. (2020).

the RBI Balance of Payments report. Table 3 presents a comparison of trade data aggregated by merchandise and services trade across the MoC, RBI, and input-output tables for 2015-16 and 2007-07 (which was published by MoSPI).

While the total trade data is matched between IOTs and other data sources, a discrepancy exists between the exports of merchandise and services—the exports of merchandise reported by IOTs are lower than those reported in other data sources. Conversely, service exports are higher. This discrepancy stems from IOTs allocating exported goods' trade and transport cost components to the relevant service sectors, while other sources include it in total merchandise exports.

CSEP-IOT 2019-20 follows the practice of earlier IOTs by allocating merchandise trade's trade and transport component to the various trade and transport sectors. The CSEP-IOT 2015-16 merchandise trade data were compared with the MoC data from the same year to compute the sectoral exports and imports for 2019-20. The sectoral ratios between the two were computed, representing the trade and transport margin of that sector's trade. Next, the MoC trade data for 2019-20 were taken for the 45 production sectors and adjusted to reduce the value of merchandise exported and increase the exports of trade and transport services.

Net Indirect Taxes

Net indirect taxes (NITs) represent the total of the indirect taxes minus subsidies, which the government levies on inputs and factors of production. NAS provides information on the total taxes paid and subsidies received by all economic sectors. The total NIT amounted to ₹18,89,670 crore. As sectoral information on NITs was not available for 2019-20, ratios of NITs to inputs for each sector were derived from the IOT 2015-16 and used for the IOT 2019-20.

Macroeconomic Data Checks

Macroeconomic data checks were conducted to ensure consistency amongst the various data sources. The GDP remained consistent when calculated using both the expenditure and income approaches. The expenditure approach for GDP is calculated by aggregating household expenditure, government

Table 4 Comparison of GDP calculation by expenditure and income approaches (current prices, 2019-20)

Expenditure Approach		Income Approach	
Component	Value (₹ crore)	Component	Value (₹ crore)
Household expenditure	1,23,09,019	Factor incomes	1,84,61,343
Government expenditure	22,85,016	Indirect taxes	22,39,222
Gross capital formation	62,71,451	Indirect subsidies	–3,49,553
Exports	37,50,567	–	–
Imports	–42,65,040	–	–
GDP (expenditure)	2,03,51,013	GDP (income)	2,03,51,013

Source: Ministry of Statistics and Programme Implementation (2021).

expenditure, gross capital formation, and net exports. The income approach for GDP is computed by aggregating incomes earned by factors of production (GVA) and incomes earned by the government (NITs). Table 4 compares the computation of GDP through the expenditure and income approaches and shows the GDP for 2019-20 in current prices: ₹2,03,51,013 crore. Government expenditure, gross capital formation, and imports were adjusted slightly to balance all components and the GDP.

These data points served as the foundation for the RAS estimation of the CSEP-IOT 2019-20.

RAS Estimation

The RAS technique was utilised to estimate the inter-industry transactions for IOT 2019-20. It is an iterative scaling method (CROS, European Commission, 2016). This methodology has been used for updating and estimating input-output for future years, for example, by Gretton & Cotterell (1979), Rao & Tommasino (2014), and Trinh & Phong (2013). The RAS technique is predicated on the assumption that the technical coefficients of production sectors (i.e., the share of sectoral inputs to the total output of the sector) would not have changed significantly in the short timespan between 2015-16 and 2019-20. Consequently, the inter-industry transactions from IOT 2015-16 can be used to project similar outcomes for 2019-20. Details of the methodology used are shown in Appendix E. The RAS method requires 'target' values, which, in the case of ESAM 2019-20, are the NAS macroeconomic data for 2019-20.

While RAS has some limitations, including carrying forward any errors in the technical coefficients of the original matrix to the updated matrix, the aggregate row and column of each sector in the ESAM is balanced with NAS data.

4.3 Extending the IOT to ESAM

Having understood the construction of the I-O tables and their application in the ESAM, we now examine other databases beyond the I-O matrix to understand their utilisation in the structure of the CSEP-ESAM. There are three sets of databases which were used for the construction of the ESAM, i.e., the National Statistical Office's (NSO) Periodic Labour Force Survey (PLFS) and Household Consumption Expenditure (HCE), National Accounts Statistics (NAS) (Ministry of Statistics and Programme Implementation, 2021) and Reserve Bank of India's (RBI) handbook of statistics. Apart from these sources, there were other data sources, which will be detailed in the following sub-sections.

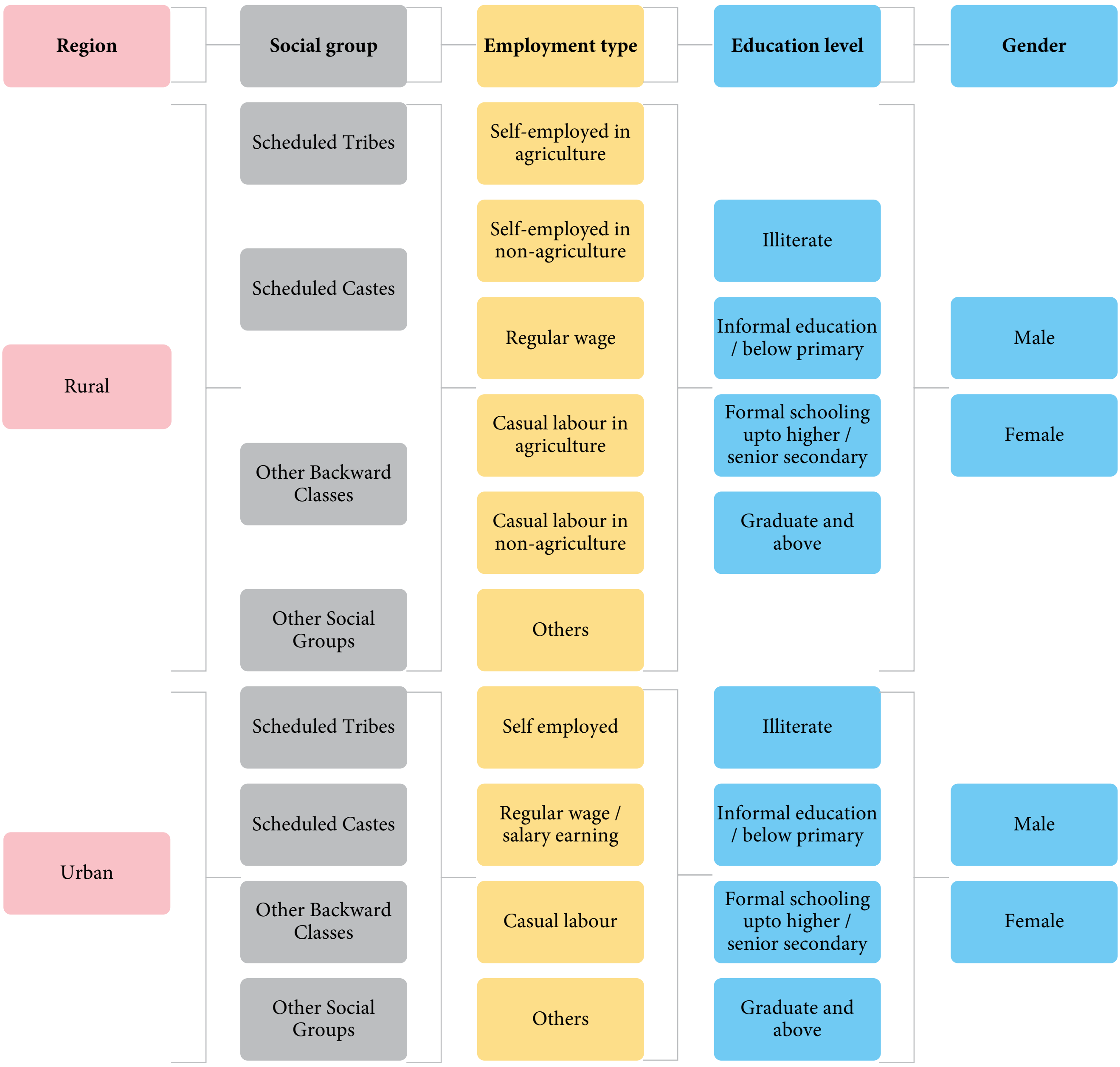
Gross Value Added

As shown in Figure 2, labour income data have been classified into five different categories:

1. region (rural and urban);
2. social groups (SC, ST, OBC and Other Social Groups);
3. occupation of households (self-employed in agriculture, self-employed in non-agriculture, regular wage, casual labour in agriculture, casual labour in non-agriculture and others);
4. educational status of individuals in households (illiterate, informal-below primary, formal-higher-senior secondary, and graduate and above); and
5. gender (male and female).

The social groups and occupational characteristics belong to households of any region, whereas educational status and gender are associated with the personal attributes of the household members. Under such classification, there are 192 categories of labour in rural areas and 128 in urban areas. While the urban areas have four household occupation categories, the rural areas have six such divisions, per the National Sample Survey Office (NSSO) categorisation. The requisite income data have been extracted from the third round of the Periodic Labour Force Survey (PLFS), surveyed in 2019-20. The PLFS survey involves conducting two to four visits for households in the urban areas and one to rural areas. Revisit data were not required as the SAM data represents the economy for a specific year. The PLFS rounds capture this revisit data to represent any sequential changes in income or labour force participation rates among the same households over time. Hence, the data for only the first visit was extracted.

Figure 2 Structure of Labour-Factor of Production Adopted in CSEP-ESAM



Note: In the CSEP-ESAM, the total number of categories in Rural area=1x4x6x4x2=192 and Urban area=1x4x4x4x2=128. Hence, there are 318 categories in rural and urban areas.

Source: Authors' Representation.

Table 5 Concordance between CSEP-ESAM and Educational Categories in PLFS

CSEP-ESAM Category	PLFS Definition
i. Illiterate	Not literate
ii. Informal education-below primary	Literate without formal schooling and literate with below primary education: Education Guarantee Scheme (EGS)-Non-formal Education Courses (NFEC), Adult Literacy Centres (AEC), Total Literacy Campaign (TLC), others; literate but below the primary
iii. Formal Schooling up to higher-senior secondary	Primary, middle, secondary, higher secondary, diploma-certificate course
iv. Graduate and above	Graduate and postgraduate and above

Source: Authors' Rrepresentation using NSO (2021).[6]

The PLFS categorises education into twelve levels, which have been consolidated into four categories for the CSEP-ESAM. The mapping of education levels in the CSEP-ESAM with the PLFS categories is provided in Table 5. The Illiterate category includes individuals with no formal or informal education. The second category represents informal education below the primary level, encompassing individuals who have either attended informal schooling, such as Education Guarantee Scheme (EGS), Non-formal Education Courses (NFEC), who can read and write but have dropped out before completing formal primary education. Third is Formal Schooling (up to higher-senior secondary level), which includes individuals who have studied up to primary, middle, secondary, and higher-secondary levels or completed diploma-certificate courses equivalent to a level below graduation. The Graduate and above category includes individuals who have completed graduate, post-graduate, or higher degrees and those who have completed diploma and certificate courses equivalent to post-graduate or above, such as a post-graduate diploma in management.

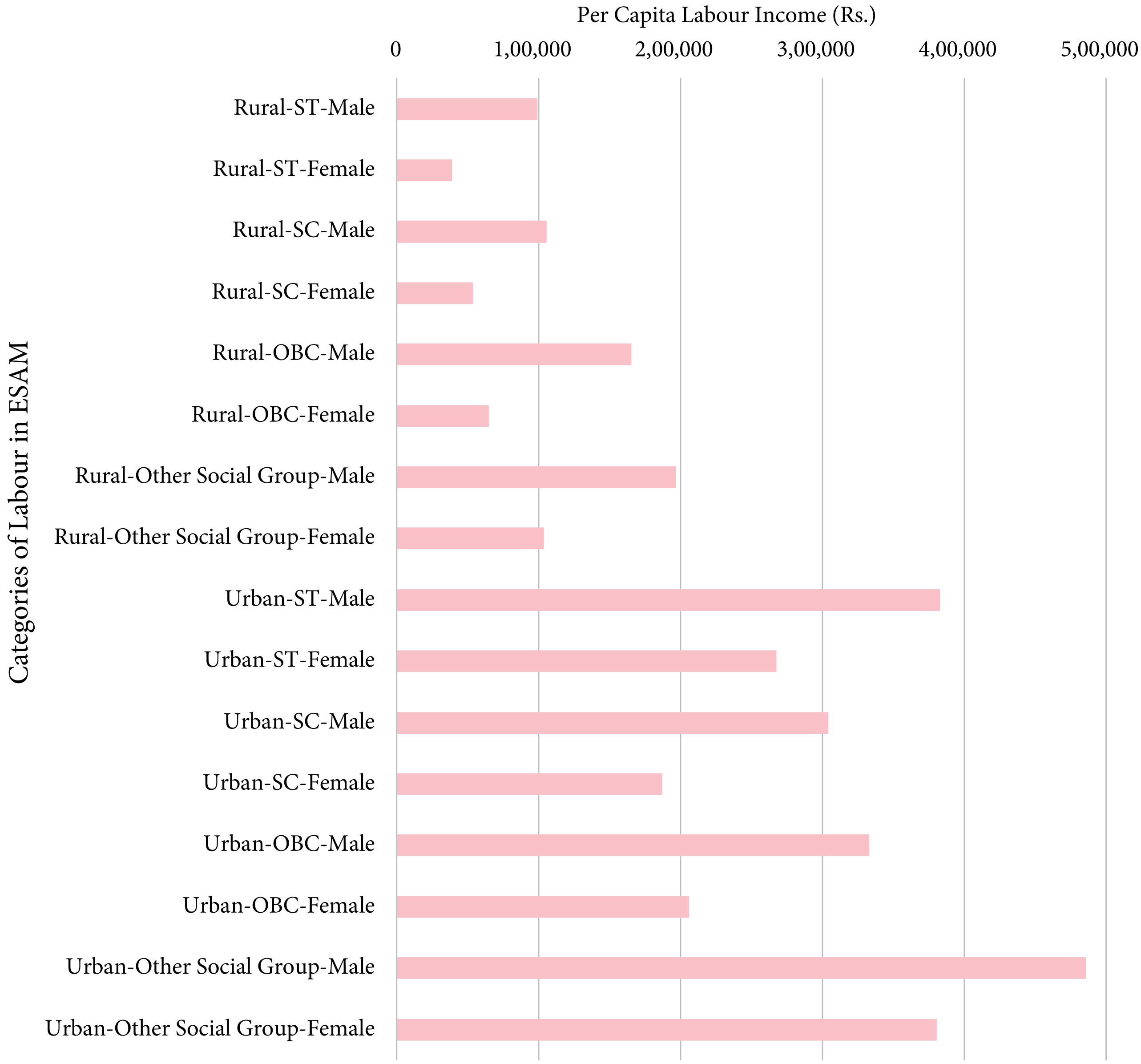
A concordance map was created, linking the 45 CSEP-ESAM sectors to the 5-digit National Industrial Classification (NIC) 2008 codes to extract labour income data from the PLFS (refer to Appendix F). This table must be prepared at the 5-digit level because the PLFS data uses this to identify the sector in which a household member is employed. The gross value added (GVA) from the PLFS was separated into labour and capital income. The process of allocating the GVA across all 45 CSEP-ESAM sectors, drawing on data obtained from the 13 sectors obtained from NAS, has been outlined in the previous section. A concordance between the sectors in the KLEMS database (Krishna et al., 2022)[7] and our CSEP-ESAM was created to use the ratios of labour incomes, as given by the KLEMS database. These KLEMS ratios were applied to the 2019-20 GVA from the NAS database to determine the total labour and capital incomes for all 45 CSEP-ESAM sectors. Once the total factor incomes for the 45 sectors were calculated, the ratios for labour income across the 318 labour categories were computed using the details in Figure 2. These ratios were applied to the total labour income for each sector from the NAS and KLEMS databases to determine the income for all 318 labour categories. These categories are represented by entry (2,1) in the CSEP-ESAM structure (see Appendix B). The per capita labour incomes for aggregated labour categories are shown in Figure 3.

Households Private Final Consumption Expenditure

The households have been classified using their social groups and decile-wise annual consumption expenditures. The 68th round of the NSSO's consumption expenditure survey is the solitary government data source that provides detailed information on households' monthly consumption expenditure for over 500 commodities for 2011-12 (NSO, 2013). Even though this report is more than a decade old, its extent of coverage is unmatched by any other database. Hence, we selected this source to obtain data on consumption expenditure, broken down by social groups and deciles. Using the 45-sector PFCE data from the IOT 2019-20, the ratios of expenditures by deciles

[6] https://dge.gov.in/dge/sites/default/files/2022-11/Annual_Report_PLFS_2019_20.pdf
[7] Reference for KLEMS https://www.rbi.org.in/Scripts/KLEMS.aspx

Figure 3 Share of Per Capita Labour Income by Category



Source: PLFS and Authors' Calculations.

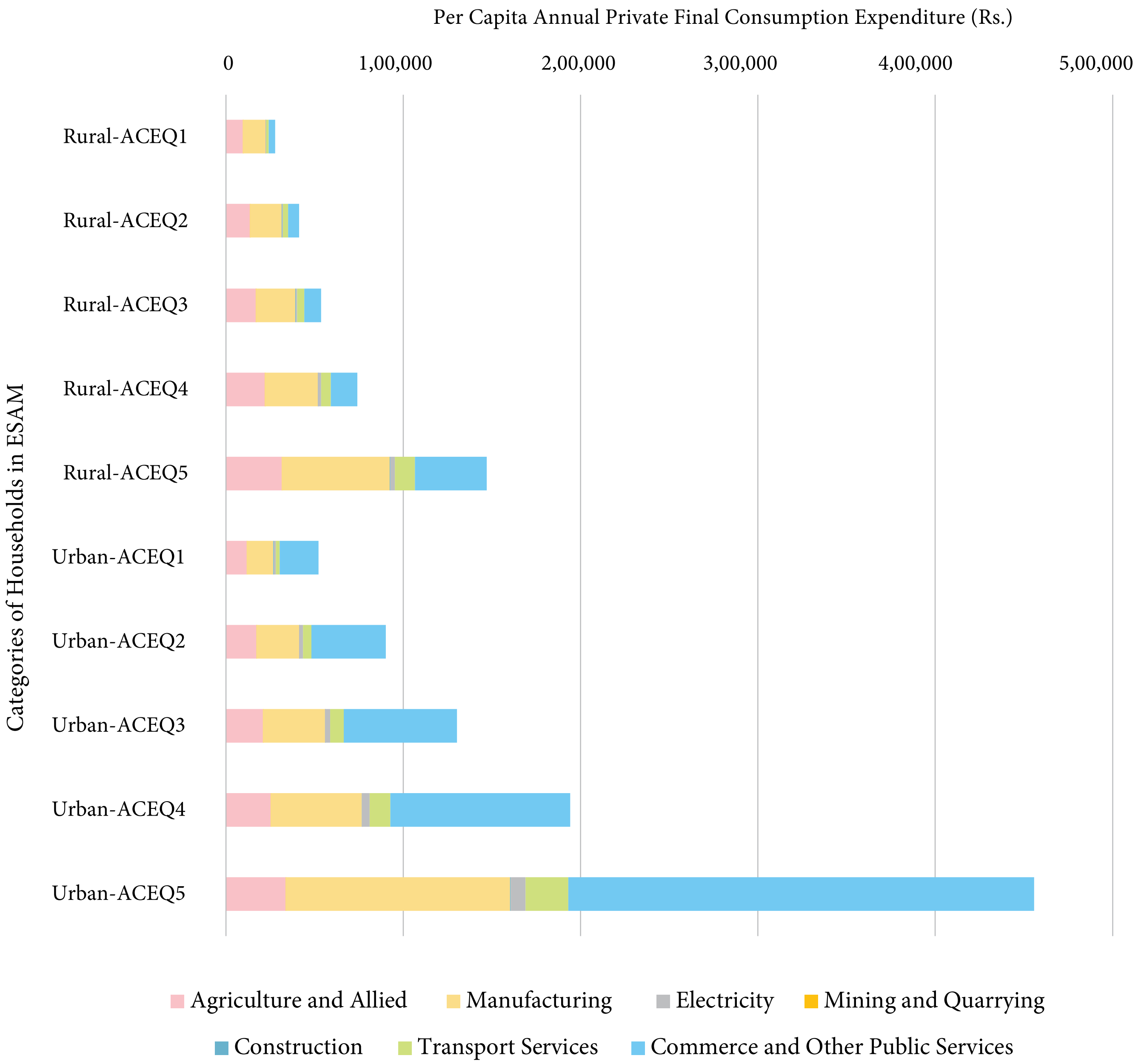
from NSSO 2011-12 were used to disaggregate the sectoral household consumption by deciles (see Annex D for NSSO to ESAM sector concordance).

The households in the ESAM have been categorised into 80 different categories based on their social group and decile-wise annual consumption expenditure. Since gender and educational characteristics are personal traits of various household members, these were dropped while extracting the PFCE data from the NSS-68th round. After disaggregating the NAS data on PFCE, we computed the updated PFCE for the 80 household categories in the required production sectors of the SAM. This was achieved using the social group/decile-wise Annual Consumption Expenditure (ACE) ratios extracted from the 68th NSSO round.[8] These were calculated for the 30 sectors of the 45 SAM productive sectors for which the PFCE data were available.[9] The percentages for all

[8] For the commodities in the NSS survey which had a recall period of a month, annualization was done by multiplying their consumption expenditure values by a factor of 12.

[9] There are several sectors such as all the mining sectors (iron ore, manganese ore, bauxite etc.), crude petroleum, natural gas etc., which the households do not consume directly and hence there is no data on their PFCE.

Figure 4 Sector- and Household Category-wise Per Capita Private Final Consumption Expenditure



Source: 68th NSSO Round and Authors' Computations.

30 sectors were multiplied successively with their individual PFCE totals obtained from the NAS. These calculations yielded the PFCE information for 2019-20, as depicted in the CSEP-ESAM structure by the entry (1,4) in Table 2.

The per capita private final consumption expenditure is shown in Figure 4 by broad sectoral groups and household categories.

Distribution of Value-Added Income

Labour Income Distribution

A distinctive feature of a social accounting matrix, as compared to I-O, is the distribution of the income earned by the factors of production from the productive sectors of an economy to the households (entry (4,2) in Appendix B). This entire flow is absent in an input-output framework. After having constructed

Table 6 Total Labour Income in the CSEP-ESAM (in Rs. Lakh)

Social Groups	ST	SC	OBC	Other Social Groups
Rural				
Labour Income	3,59,02,096	7,25,49,786	20,93,16,110	12,40,13,064
Net Factor Income from Abroad	77,195	1,55,993	4,50,060	2,66,646
Total Labour Income, including Net Factor Income	3,59,79,291	7,27,05,779	20,97,66,170	12,42,79,711
Urban				
Labour Income	1,83,11,471	6,08,60,264	18,61,82,439	25,87,52,774
Net Factor Income from Abroad	39,372	1,30,858	4,00,319	5,56,356
Total Labour Income, including Net Factor Income	1,83,50,843	6,09,91,123	18,65,82,758	25,93,09,130

Source: Authors' Computations using NSO (2021), MoSPI (2022) and RBI (2021).

the labour and capital incomes for the 318 categories of labour and one category of capital, the distribution of this income and the net factor income from abroad to the 80 classes of households is required. The first component of total labour income is the labour income, as indicated by entries (2,1) and (2,10) in Appendix B, whose calculation was explained in previous sections. The other component is the aggregated NFIA from the RBI (2021), which needs to be distributed across the 318 categories. This was done by applying the ratios of factor income to the NFIA. The total labour income (consisting of NFIA) was thus constructed for the 318 categories of labourers. Table 6 illustrates the decomposition of total labour incomes across rural and urban regions and the four social groups.

These incomes from the 318 labour categories were allocated to the 80 household categories. A significant divergence seems to exist between the allocation order due to removing personal characteristics, such as gender and educational qualifications, when forming the household classes. Furthermore, deciles were created for each social group from rural and urban households to comprehend potential inequality between households better. The 318 categories of labour incomes were thus mapped to 80 categories of households. The factor incomes are transferred to the households using the ratios of the annual consumption expenditures, which were calculated separately for each social group. For instance, the total ACE of a Scheduled Tribe household in the rural area was calculated, and then the ratio for every decile of this ST household class was taken from this total. This was done because the labour earnings by an ST household residing in the rural area will be transferred to its household in the rural area and not to a household belonging to any other social group in the rural or urban area. Based on this rationale, ratios were calculated separately for each household class.[10] These ratios were then multiplied by the total labour income for each of the 320 labour categories.

Capital Income Distribution

The capital income of an ESAM comprises four components: operating profits (5,3),[11] operating surplus (6,3), entrepreneurial income (7,3), and capital income of households. The first three components have been taken directly from the MOSPI (2022). The depreciation of the capital (refer to entry (9,3) in Appendix B) has also been taken from the NAS.

[10] ST, SC, OBC and others for each rural and urban areas and hence the total being eight categories in the entire India

[11] The numbers in the parenthesis represent corresponding rows and columns. For example, (5,3) represents fifth row and third column i.e., the interaction between Private Corporate and Capital-factor of production. This represents their operating profits (refer to Appendix B).

The total capital income of households was estimated as the residual between the row total for the capital sector and the sum of operating profits, operating surplus, and income from entrepreneurship. This was done to maintain the inherent equality of row and column totals in an ESAM. After obtaining the total capital income of the households, it was distributed among the 80 household categories based on the ratios of their annual consumption expenditures.

Government

Income

The government sector receives incomes from five sectors: entrepreneurship (7,3), income and wealth taxes (7,4), corporate taxes (7,5), total net indirect taxes (7,8), and net capital transfers (7,10). This section will detail the computation of the income and wealth taxes (7,4) and total net indirect taxes (7,8).

Income and wealth taxes (7,4) refer to the taxes received by the government from the income and wealth of households. This value was ₹12,06,046 crore in 2019-20 (MoSPI, 2022). Of the 80 household accounts, the tax payable was allocated to just 4: urban-ST-ACE10, urban-SC-ACE10, urban-OBC-ACE10, and urban-other social groups-ACE10. This was done because only the top decile in India pay taxes, and a significant portion of the rural region's income, which is agriculturally based, is exempt from income tax. The income and wealth tax received by the government was split proportionally using the share of the per capita value-added income of these four household groups.

The total net indirect taxes (7,8) received by the government is the sum of all the net indirect taxes paid by the various sectors (by the production sectors (8,1), households (8,4), government (8,7), capital formation (8,9), and on exports (8,10)).

Expenditure

The expenditure of government sectors encompasses direct government consumption of goods and services (1,7), transfer payments and interest on debt to the households (4,7), interest on debt to private corporates (5,7), taxes on purchases (8,4) and government's savings (9,7). The government's consumption and taxes on purchases have been sourced from the CSEP-I-O-2019-20 and have already been covered. The details of the government's savings will be discussed in the section on capital accounts.

The transfer payments consist of other current transfers, totalling Rs. 20,01,733 crore (MOSPI, 2022). In the ESAM, transfer payments are combined with interest on household debt, representing the income households receive from the government for capital investments such as bonds and shares (entry 4,7). The capital (factor) income ratios calculated earlier for each category were used to allocate this amount across the eighty household categories.

Interest on debt data came from the Ministry of Finance (2022) and was divided between households and private corporates based on their capital income ratios. The total interest on the debt was around Rs. 6,45,951 crore. This was allocated to households and capital by their corresponding ratios of around 79% and 21%. After that, the proportions of households' capital (factor of production) incomes were used to allocate the aggregated households' share in the total interest on the debt. The sum of household transfer payments and household shares of total debt comprised the ESAM entry (4,7) for government transfers to households. The private corporates' 21% share in the total interest on debt completes the ESAM entry of (5,7).

Rest of the World (ROW)

The ROW expenditures account in an ESAM comprises exports, Net Factor Income (NFI), net current transfers to households (also known as remittances), net capital transfers to the government, taxes on exports and foreign savings. Here, we will be detailing the construction method of NFI, net current transfers and net capital transfers, as the other entries in the ESAM have already been discussed in the previous sections.

The NFI, obtained from the RBI (2021), separately presents the net compensation of employees (totalling Rs. 20,768 crore) and net investment income[12] (Rs. -2,13,882 crore). The net compensation of employees was used for the NFI, representing the interaction between the capital factor and ROW in the CSEP-ESAM. The compensation of employees from ROW should be allocated to the 318 categories of labourers in the ESAM. For this, we used the

[12] This is also a part of the NFI as it is the amount received by the capital-factor of production from the ROW.

Table 7 Data sources and their explanations

Sl. No.	Details of the Data	Data Source	Reason for Selection
1.	CSEP-Hybrid Energy Input-Output-2015-16	Chadha and Sivamani (2022)	In-house availability of comprehensive data
2.	Input-Output-2019-20	Constructed at CSEP	No recent I-O table is available; hence constructed CSEP's I-O table
3.	Labour Incomes	PLFS-2019-20-NSO (2021)	A relevant year and the most reliable source
4.	Ratios of households' consumption and expenditure	NSS-68th round-2011-12-NSO (2013)	The most recent NSS survey on consumption and expenditure
5.	Various macroeconomic parameters for 2019-20	MoSPI (2022)	Most reliable macroeconomic data
6.	Exports and imports of services, net factor income, remittances, net capital transfers	RBI (2021)	Authentic government source
7.	Shares of labour and capital for distributing incomes between labour and capital	KLEMS Database, Krishna et al. (2022)	A most recent and reliable source
8.	Ratios of remittances for distribution across social groups, regions and deciles of households	NSS-Migration survey-2007-08-NSSO (2010)	The most recent NSS survey

Source: As mentioned in the table.

ratios of the value added within these categories. In the case of net investment income, the net value of Rs. -2,13,882 crore was mentioned in the cell, which depicts an interaction between the capital factor of production in the row and the Rest of the World in the column.

The net current transfers from the ROW to the households, i.e., remittances, are given in the RBI (2021). This amounts to Rs. 5,40,364 crore, which needs to be allocated to our ESAM's 80 categories of households, which are categorised based on region, social group and deciles of their ACE. First, the proportions of remittances by region, social group, and decile were calculated using NSSO (2010) data. After this, we computed their ratios and used these proportions to allocate the total remittances in India in 2019-20 as obtained from RBI (2021). To the best of our knowledge, this is the latest reliable source which provides the allocation of remittances in India across regions, social groups and deciles.

The interaction between the government's receipts from and expenditure to ROW, depicting the net capital transfers, is also a one-to-one interaction, sourced from the RBI (2021) and totals Rs. -7,158 crore.

Capital Account (Investment-Savings)

The receipts of the capital account sector (also referred to as the investment-savings account) in the ESAM represent savings for all the relevant interactions except for the interaction between the capital account and the capital factor of production, which depicts the depreciation of the capital. The expenditure by the capital factor of production, referred to as depreciation (refer to the entry (9,3) in Appendix B) in the ESAM, has been taken directly from the MOSPI (2022). The savings of households, private corporates, the government, and the ROW sectors are the residual amounts from their respective receipts and expenditure totals. For example, households' savings, represented by entry (9,4) in Appendix B, is the residual of the sum of the households' receipts (row total) and expenditures (column total). This is because, by definition, the row and column totals of every sector in an ESAM are equal and further savings are the residual of income and expenditure. Therefore, this justifies the method of creating a capital account that portrays the savings of various sectors. For public non-departmental entities, receipts (6,3) represent the operating surplus obtained from MOSPI (2022). This operating surplus also comprises their savings (expenditures) (Pradhan et al., 2006).

Table 8 Consistency Checks

Component	National Accounts (₹ crore)	CSEP ESAM (₹ crore)	% Difference
Household expenditure	1,23,09,019	1,23,09,019	0.0
Government expenditure	22,85,016	22,85,016	0.0
Gross capital formation	62,71,451	62,71,451	0.0
Exports	37,50,567	37,50,567	0.0
Imports	42,65,040	42,65,040	0.0
Factor incomes	1,84,61,343	1,84,61,343	0.0
Net Indirect Taxes	18,89,669	18,89,669	0.0
Savings-Investments	59,95,942	62,71,451	+4.6

Source: National Accounts Statistics (2021), Reserve Bank of India (2022) and Authors' Calculations.

Table 7 summarises the various data sources and their justifications for constructing CSEP-ESAM.

4.4 Consistency Checks

The CSEP-ESAM utilises the macroeconomic data from the National Accounts Statistics; thus, there are no discrepancies between these values in the ESAM and NAS. As mentioned in the previous section, the capital account (also called the savings-investments account) values are computed as the difference in revenues and expenditures for each sector. As a consistency check, the aggregate values from each account to the capital account in the ESAM have been compared with data from the Reserve Bank of India. The CSEP-ESAM exhibits 4.6% higher savings than the value reported by RBI, implying that certain ESAM accounts report higher incomes or lower expenditures than the actual figures. A discrepancy exists in the government account whereby property income was omitted from the ESAM framework to align with other Indian SAM structures. Like the CSEP ESAM, other SAMs for India also encounter balancing issues in the savings-investment account because some transactions are not recorded. Table 8 below summarizes these checks.

4.5 Data Limitations

Some assumptions have been made in constructing the ESAM due to the non-availability of required data. While many have been discussed in this section, the following highlights some of the key assumptions:

- Quality of data:
  - All macroeconomic data have been sourced from officially published outlets, particularly MoSPI and RBI.
- Limitations in basing the ESAM on the SUT for India 2015-16:
  - Any peculiarities with the technical coefficients from the SUT may be transferred to the ESAM.
  - The RAS methodology has been used to determine the technical coefficients of 2019-20 based on information available in 2015-16. While the macroeconomic aggregates have been matched with national accounts statistics, there may be some irregularities in certain intersectoral transactions.
- Assumptions due to data unavailability:
  - Assumptions have been made in determining the labour income transfers to households, based on their respective categories.
  - The total production and sectoral electricity consumption have been divided based on the kilowatt-hour generation quantity. It has been assumed that each electricity generation source sends its electricity to a fungible pool, where all sectors can purchase the commodity without knowing its source.
  - Generation and treatment of wastewater and degradation and land replenishment have been used as proxies for water and pollution, respectively.
  - Various interactions between households and the government (such as wealth tax payment and government bond interest payment to households) have been disaggregated based on existing literature, as detailed data are unavailable.

5. Social Accounting Matrix Analysis

5.1 SAM Multipliers

The Social Accounting Matrix enables assessment of the economic impact of a policy change (or 'shock') by calculating 'multipliers' that quantify the effects. Shocks refer to an event that affects the economy, which can include an increase in the production subsidy for a sector, the imposition of a carbon tax, or increased productivity in a sector. The SAM can demonstrate how alterations in a sector's final demand ripple through the economy, affecting outputs, incomes, jobs, and emissions. SAM multipliers measure the total changes in an economy due to a unit change in a given sector (a unit-less measure). They incorporate *direct effects* on economic agents (e.g. increasing a sector's output requires more inputs), *indirect effects* (e.g. more inputs cause other sectors to raise outputs), and *induced impacts* (e.g. higher outputs increase incomes and spending, further raising outputs) (Miller & Blair, 2009).

As these multipliers are derived from the SAM, they are *comparative static*. They compare the structure of an economy before and after an exogenous demand change (independent, with changes determined outside the defined model) and show the new equilibrium state of the economy. SAMs also serve as the key database for computable general equilibrium models, which are used further in policy modelling. CGE models combine economic theory with the database to predict how the economy would change due to policy shocks. Unlike SAMs, supply-side restrictions can be applied to CGE models; for example, where a SAM multiplier may show that labour income can be increased given additional final demand for a sector, the CGE model would consider the available supply of labour and their substitutability from one sector to another.

While social accounting matrices are valuable tools for policy analysis, some inherent limitations exist. The technical coefficients embedded in the SAM represent average production functions and consumer behaviours. Marginal changes in taxes, prices, or technologies could alter relative costs and cause substitution effects between sectors. Non-linearities may also arise, whereby small changes have a disproportionate impact due to slack capacity or inducing major structural shifts. The existence of unused resources or available substitutes implies the economy may have more flexibility than reflected in fixed SAM multipliers.

Furthermore, prices and external competitiveness effects are excluded. Finally, these multipliers represent a new equilibrium compared to the base SAM structure and do not depict the path to equilibrium. These limitations suggest SAM analyses should be interpreted as an indicative quantification of policy impacts. More robust results can be obtained using SAMs alongside other modelling techniques, such as CGE models.

5.2 Multipliers from CSEP-ESAM – Worked Examples

This section details the steps taken to compute various multipliers from a SAM. A standard SAM multiplier is defined as the ratio of the change in an economic variable due to a unit change (shock) to one sector, giving a unit-less value. Other variations of multipliers can also be calculated, such as determining the impact on employment or emissions due to the shock, which are further described in this section.

Firstly, the sectors of the ESAM have been classified as either exogenous (the sectors to which the policy shock will be applied) or endogenous (the sectors that will be affected by the policy shock). For this analysis, the government, indirect taxes, capital, exports, and imports accounts were treated as exogenous. Thus, all multipliers in these worked examples are defined as the ratio of the change in an economic indicator to an exogenous unit demand increase of a given sector. The increased exogenous demand, that is, additional final demand, may encompass increased export demand, reduced import demand, increased subsidies, reduced taxes, additional government spending, or increased investments. As monetary values in the ESAM are measured in lakhs, the exogenous demand unit increase in these worked examples is ₹1 lakh.

Additionally, to simplify this analysis, the 318 labour categories have been consolidated into 32, and 80 household categories have been reduced to 40 (Table 9). This arrangement can be altered following policy analysis requirements. In the aggregated ESAM used in the worked example, there are 120 endogenous and 4 exogenous accounts.

Table 9 Aggregation of ESAM for Multipliers Worked Examples

	Accounts	CSEP ESAM	Aggregated ESAM
Endogenous	Production Sectors	45 sectors	45 sectors
	Labour Factor of Production	318 labour categories 2 Regions 4 Social Groups 6 Employment Types (Rural) and 4 Employment Types (Urban) 4 Education Levels 2 Sexes	32 labour categories 2 Regions 4 Social Groups – 2 Education Levels 2 Sexes
	Capital Factor of Production	1 capital	1 capital
	Households	80 household categories 2 Regions 4 Social Groups 10 Annual Consumption Categories	40 household categories 2 Regions 4 Social Groups 5 Annual Consumption Categories
	Institutions	2 institutions	2 institutions
Exogenous	Government	2 government sectors	2 government sectors
	Capital Account	1 capital account	1 capital account
	Rest of World	1 rest of the world account	1 rest of the world account

Source: Authors' Elaboration.

Based on this categorisation, the CSEP-ESAM can be represented as the sum of the endogenous and exogenous matrices:

$$\mathbf{S} = \begin{pmatrix} \mathbf{A} & \mathbf{0} & \mathbf{C} & \mathbf{0} \\ \mathbf{V} & \mathbf{0} & \mathbf{0} & \mathbf{0} \\ \mathbf{0} & \mathbf{Y} & \mathbf{0} & \mathbf{0} \\ \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0} \end{pmatrix} + \begin{pmatrix} \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{F}_{1,4} \\ \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{F}_{2,4} \\ \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{F}_{3,4} \\ \mathbf{F}_{4,1} & \mathbf{F}_{4,2} & \mathbf{F}_{4,3} & \mathbf{F}_{4,4} \end{pmatrix}$$

$$\mathbf{S} = \mathbf{D} + \mathbf{X}$$

Where:

S represents the SAM,

A represents the inter-sectoral transactions,

C represents the household-wise consumption,

V represents the incomes to the factors of production,

Y represents the transfer of incomes from the factors of production to the households,

F represents the various exogenous accounts,

D represents the aggregate endogenous matrix,

X represents the aggregate exogenous matrix.

The following forms the basis of computing SAM multipliers:

$$\mathbf{M} = (\mathbf{I} - \mathbf{D})^{-1}$$

Where:

M represents the multipliers matrix,

I represents the identity matrix,

D represents the aggregate endogenous matrix.

Output Multipliers

The output multiplier refers to the ratio of the change in the economy's total output to an exogenous unit increase in the demand of a given sector, giving a unit-less value. It is also feasible to decompose this output multiplier into the various effects that induce economic changes. The total SAM output multipliers, denoted as *M*, which capture all economic effects,

Table 10 Decomposition of SAM Multipliers

Description	Multiplicative	Additive	Relationship
Own effects	M_1	N_1	$N_1 = M_1$
Open loop	M_2	N_2	$N_2 = M_2M_3M_1 - M_3M_1$
Closed loop	M_3	N_3	$N_3 = M_3M_1 - M_1$
Total SAM (M)	$= M_3M_2M_1$	$= N_1 + N_2 + N_3$	$= M$

Source: Miller & Blair, 2009.

can be decomposed into (a) own effects, also known as Leontief output multipliers, referring to the inter-industry effects; (b) open loop effects, demonstrating how exogenous changes transmit to households, excluding income feedbacks; and (c) closed loop effects that incorporate income feedbacks (Miller & Blair, 2009). The SAM multipliers can be decomposed by multiplicative or additive methods (Table 10).

The resulting SAM multipliers are extracted from the multipliers matrix of dimension 120x120, representing the 120 endogenous sectors utilised in this analysis. Each column element represents the additional output generated due to an exogenous demand increase of ₹1 lakh[13] to sector *i*. The summation of the entire columns, or parts thereof, leads to insights into the specific sector. For example, the sum of the entries of column *i*, referred to as *output multipliers*, shows how the outputs of all sectors change due to an increase of ₹1 lakh in the final consumption of sector *i*. Larger output multipliers point towards sectors which can better transfer the benefits of additional final consumption to the rest of the economy.

The output multipliers represent a separate experiment in which ₹1 lakh is added to the exogenous account for that sector (Table 11). For example, if there were an additional ₹1 lakh investment in Paddy, the economy's total output would increase by ₹6.38 lakh. These can also be decomposed (in this case, additive decomposition) to highlight where the most significant benefits arise. For example, while the Food & Tobacco sector has the most significant output multiplier, Other Thermal Electricity has the largest own-effect multiplier, and Livestock has the most significant open and closed loop multipliers. The primary agriculture sectors (paddy and agriculture) have the most significant output multipliers due to their higher open and closed loop multipliers (i.e., transferring income to households and increasing household expenditures). Industrial sectors like Other Thermal Electricity, metal production, Food & Tobacco, and Textiles & Leather have the highest own-effect multipliers. These results are illustrated in Figure 5.

Table 11 CSEP ESAM Output Multipliers

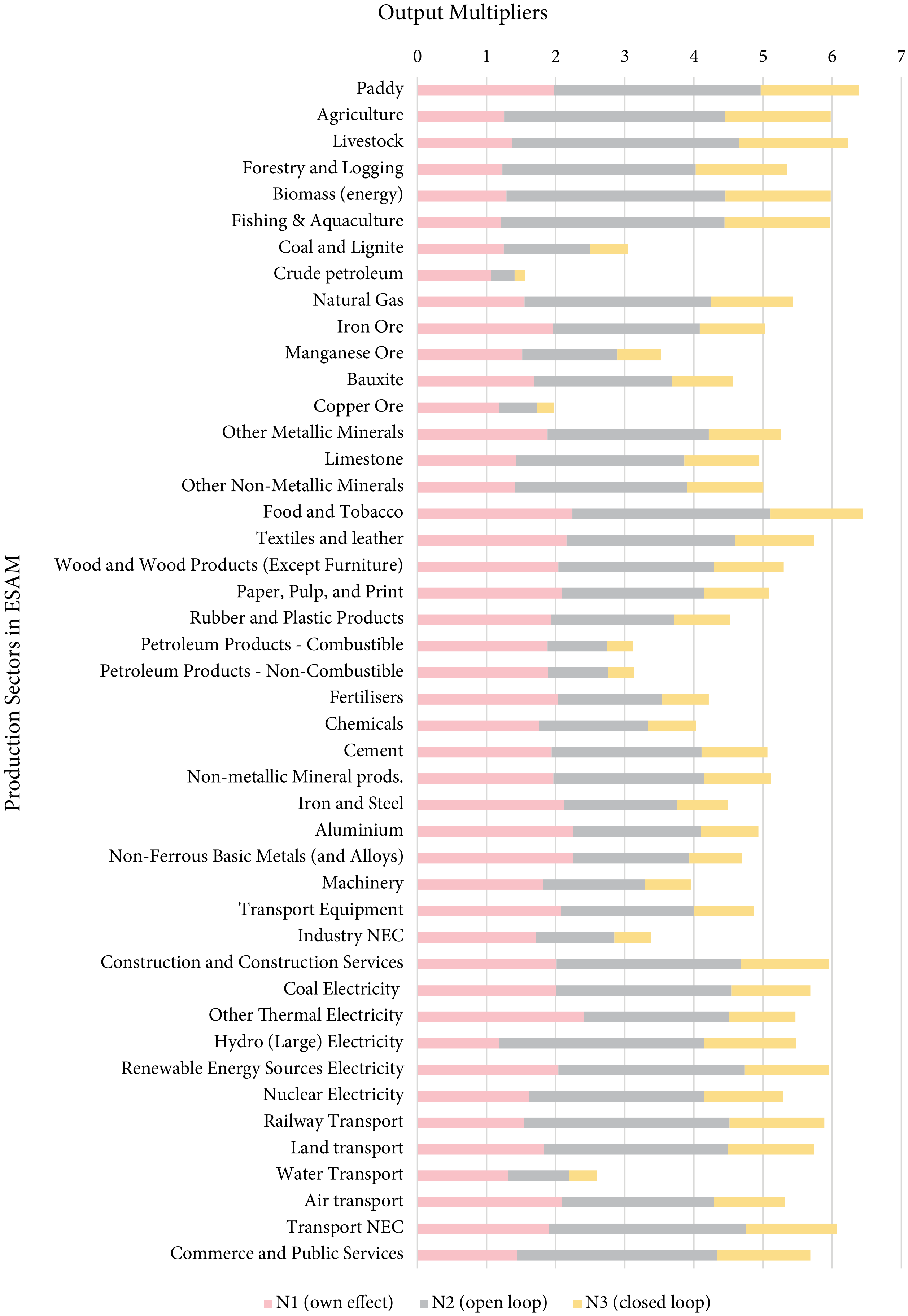
Sector	Output Multipliers			
	N1 (own effect)	N2 (open loop)	N3 (closed loop)	N (total)
Paddy	1.976	2.988	1.416	6.380
Agriculture	1.253	3.194	1.532	5.980
Livestock	1.374	3.287	1.569	6.230
Forestry and Logging	1.229	2.793	1.331	5.353
Biomass (energy)	1.287	3.170	1.520	5.977
Fishing & Aquaculture	1.212	3.228	1.533	5.973
Coal and Lignite	1.248	1.248	0.547	3.044
Crude petroleum	1.065	0.342	0.151	1.558

13 The unit of measurement for the CSEP ESAM is in lakhs of rupees.

Sector	Output Multipliers			
	N1 (own effect)	N2 (open loop)	N3 (closed loop)	N (total)
Natural Gas	1.549	2.697	1.182	5.428
Iron Ore	1.961	2.124	0.937	5.022
Manganese Ore	1.518	1.378	0.623	3.519
Bauxite	1.693	1.984	0.881	4.559
Copper Ore	1.175	0.555	0.251	1.981
Other Metallic Minerals	1.884	2.330	1.048	5.262
Limestone	1.423	2.440	1.084	4.947
Other Non-Metallic Minerals	1.413	2.486	1.105	5.004
Food and Tobacco	2.241	2.864	1.337	6.443
Textiles and leather	2.156	2.446	1.131	5.733
Wood and Wood Products (Except Furniture)	2.041	2.249	1.008	5.298
Paper, Pulp, and Print	2.090	2.060	0.935	5.086
Rubber and Plastic Products	1.930	1.780	0.812	4.521
Petroleum Products - Combustible	1.883	0.856	0.378	3.117
Petroleum Products - Non-Combustible	1.892	0.864	0.382	3.138
Fertilisers	2.030	1.509	0.677	4.216
Chemicals	1.756	1.576	0.696	4.029
Cement	1.941	2.168	0.955	5.064
Non-metallic Mineral prods.	1.969	2.177	0.971	5.117
Iron and Steel	2.118	1.636	0.737	4.490
Aluminium	2.246	1.855	0.831	4.932
Non-Ferrous Basic Metals (and Alloys)	2.249	1.682	0.764	4.695
Machinery	1.816	1.471	0.669	3.956
Transport Equipment	2.077	1.928	0.863	4.867
Industry NEC	1.711	1.141	0.525	3.377
Construction and Construction Services	2.015	2.667	1.267	5.949
Coal Electricity	2.004	2.534	1.148	5.686
Other Thermal Electricity	2.408	2.102	0.957	5.467
Hydro (Large) Electricity	1.181	2.968	1.323	5.471
Renewable Energy Sources Electricity	2.037	2.691	1.230	5.957
Nuclear Electricity	1.614	2.533	1.137	5.284
Railway Transport	1.541	2.970	1.373	5.885
Land transport	1.828	2.664	1.242	5.734
Water Transport	1.316	0.879	0.405	2.600
Air transport	2.085	2.208	1.024	5.317
Transport NEC	1.900	2.850	1.322	6.072
Commerce and Public Services	1.438	2.894	1.350	5.683

Source: Authors' Computations.

Figure 5 CSEP ESAM Output Multipliers



Source: Authors' Elaboration.

Labour Income Multipliers

The output multipliers example demonstrates that various aggregated sums can be extracted from the multiplier column. Similar to how the output of a sector can be broken down into inputs, factor payments, and net indirect taxes, the multipliers can also be disaggregated. This includes the labour income multiplier, which signifies the effect of an exogenous change on the incomes of the labour categories.[14] This can be further disaggregated by the specific labour category, as demonstrated in Table 12.

Table 12 Labour Income Multipliers

Sector	Total	Region		Social Group				Gender	
		Rural	Urban	ST	SC	OBC	Others	Male	Female
Paddy	0.844	0.558	0.286	0.084	0.135	0.343	0.283	0.719	0.125
Agriculture	0.923	0.700	0.223	0.074	0.158	0.409	0.282	0.790	0.133
Livestock	0.952	0.670	0.282	0.066	0.127	0.446	0.312	0.747	0.205
Forestry and Logging	0.808	0.479	0.330	0.118	0.109	0.233	0.348	0.732	0.077
Biomass (energy)	0.917	0.647	0.270	0.061	0.244	0.380	0.232	0.820	0.097
Fishing & Aquaculture	0.933	0.598	0.334	0.058	0.183	0.439	0.252	0.849	0.084
Coal and Lignite	0.282	0.101	0.181	0.020	0.044	0.116	0.101	0.245	0.037
Crude petroleum	0.077	0.035	0.042	0.008	0.008	0.031	0.030	0.069	0.008
Natural Gas	0.603	0.208	0.396	0.025	0.080	0.297	0.201	0.542	0.061
Iron Ore	0.484	0.196	0.288	0.057	0.054	0.187	0.185	0.431	0.053
Manganese Ore	0.335	0.176	0.159	0.067	0.039	0.119	0.110	0.293	0.041
Bauxite	0.474	0.165	0.309	0.022	0.054	0.249	0.150	0.415	0.059
Copper Ore	0.135	0.071	0.065	0.027	0.015	0.048	0.045	0.118	0.018
Other Metallic Minerals	0.552	0.294	0.258	0.116	0.063	0.194	0.180	0.484	0.068
Limestone	0.549	0.326	0.223	0.026	0.067	0.284	0.172	0.491	0.059
Other Non-Metallic Minerals	0.563	0.298	0.265	0.040	0.095	0.237	0.191	0.498	0.065
Food and Tobacco	0.784	0.455	0.329	0.054	0.116	0.330	0.283	0.654	0.131
Textiles and leather	0.665	0.307	0.357	0.036	0.096	0.278	0.255	0.550	0.115
Wood and Wood Products (Except Furniture)	0.527	0.283	0.245	0.039	0.075	0.226	0.188	0.466	0.061
Paper, Pulp, and Print	0.529	0.211	0.317	0.030	0.072	0.217	0.209	0.460	0.069
Rubber and Plastic Products	0.460	0.196	0.264	0.030	0.063	0.172	0.196	0.396	0.065
Petroleum Products - Combustible	0.193	0.082	0.112	0.012	0.027	0.077	0.078	0.167	0.026
Petroleum Products - Non-Combustible	0.195	0.082	0.113	0.012	0.025	0.077	0.082	0.169	0.027
Fertilisers	0.361	0.169	0.192	0.020	0.047	0.137	0.157	0.309	0.052

[14] These multipliers are quantified as the change in labour income per exogenous demand unit (₹ lakh) change. The labour income coefficients, on the other hand, represent the share of labour income earned in a sector to that sector's output. The results of both are available in Appendix G. It should be noted that these terms should not be directly compared, as the denominators are different.

Sector	Total	Region		Social Group				Gender	
		Rural	Urban	ST	SC	OBC	Others	Male	Female
Chemicals	0.353	0.156	0.197	0.021	0.049	0.139	0.144	0.301	0.052
Cement	0.483	0.216	0.267	0.036	0.069	0.199	0.179	0.424	0.059
Non-metallic Mineral prods.	0.506	0.245	0.261	0.033	0.078	0.205	0.191	0.440	0.066
Iron and Steel	0.405	0.167	0.239	0.031	0.053	0.158	0.164	0.352	0.053
Aluminium	0.452	0.174	0.278	0.026	0.060	0.169	0.197	0.394	0.058
Non-Ferrous Basic Metals (and Alloys)	0.432	0.175	0.257	0.027	0.055	0.167	0.182	0.370	0.062
Machinery	0.379	0.150	0.228	0.021	0.051	0.148	0.159	0.327	0.052
Transport Equipment	0.463	0.190	0.273	0.026	0.062	0.180	0.194	0.402	0.061
Industry NEC	0.307	0.132	0.175	0.018	0.041	0.126	0.122	0.267	0.041
Construction and Construction Services	0.806	0.392	0.414	0.041	0.102	0.369	0.293	0.711	0.095
Coal Electricity	0.646	0.252	0.395	0.033	0.090	0.253	0.270	0.558	0.088
Other Thermal Electricity	0.549	0.217	0.332	0.029	0.075	0.241	0.205	0.471	0.078
Hydro (Large) Electricity	0.689	0.340	0.349	0.047	0.082	0.296	0.264	0.622	0.067
Renewable Energy Sources Electricity	0.703	0.298	0.405	0.034	0.100	0.286	0.283	0.610	0.094
Nuclear Electricity	0.594	0.354	0.241	0.023	0.091	0.341	0.139	0.539	0.055
Railway Transport	0.835	0.308	0.527	0.044	0.156	0.331	0.304	0.746	0.090
Land transport	0.746	0.358	0.387	0.044	0.114	0.308	0.280	0.659	0.087
Water Transport	0.242	0.090	0.152	0.011	0.036	0.100	0.095	0.215	0.027
Air transport	0.616	0.233	0.383	0.031	0.078	0.220	0.287	0.506	0.110
Transport NEC	0.799	0.311	0.488	0.044	0.119	0.307	0.329	0.697	0.102
Commerce and Public Services	0.824	0.335	0.489	0.045	0.115	0.311	0.352	0.678	0.146

Source: Authors' Computations.

These multipliers could indicate to policymakers the sectors that have the potential to enhance labour incomes for specific demographic groups significantly. For example, a ₹1 lakh investment (i.e., exogenous demand change in investments) in Railway Transport leads to a ₹0.84 lakh rise in total incomes, with most of this increase going to the urban region. This income rise relates to the changes throughout the economy, not specifically in the Railway Transport sector. Similarly, investing in the Forestry & Logging sector would benefit the ST social group the most. The labour income multipliers are higher for male workers than female workers in all production sectors. Investing in the Livestock sector provides female workers with the most significant gains in labour income. This sector also provides more equitable gains to male and female workers (the male labour income multiplier is only 3.6x greater than the female counterpart) compared to the Fishing sector, where male labour income would be 10.1x more than the female labour income.

Table 13 provides the sectors with the most substantial impact on labour income by social group.

Table 13 Labour Category Income Multipliers – Sectors with Largest Multipliers

Region	Social Group	Sex	Education Level	Sector	Sector Type	Multiplier
Rural	ST	Male	< Primary	Paddy	Agriculture	0.027
			≥ Primary	Other Metallic Minerals	Mining	0.101
		Female	< Primary	Livestock	Agriculture	0.008
			≥ Primary	Fishing & Aquaculture	Agriculture	0.007
	SC	Male	< Primary	Agriculture	Agriculture	0.045
			≥ Primary	Biomass (energy)	Agriculture	0.172
		Female	< Primary	Livestock	Agriculture	0.019
			≥ Primary	Livestock	Agriculture	0.009
	OBC	Male	< Primary	Biomass (energy)	Agriculture	0.118
			≥ Primary	Agriculture	Agriculture	0.186
		Female	< Primary	Livestock	Agriculture	0.046
			≥ Primary	Livestock	Agriculture	0.033
	Others	Male	< Primary	Fishing & Aquaculture	Agriculture	0.057
			≥ Primary	Agriculture	Agriculture	0.120
		Female	< Primary	Livestock	Agriculture	0.011
			≥ Primary	Livestock	Agriculture	0.025
Urban	ST	Male	< Primary	Railway Transport	Service	0.003
			≥ Primary	Iron Ore	Mining	0.020
		Female	< Primary	Aluminium	Industrial	0.002
			≥ Primary	Commerce and Public Services	Service	0.004
	SC	Male	< Primary	Fishing & Aquaculture	Agriculture	0.014
			≥ Primary	Railway Transport	Service	0.076
		Female	< Primary	Construction and Construction Services	Industrial	0.003
			≥ Primary	Transport NEC	Service	0.009
	OBC	Male	< Primary	Biomass (energy)	Agriculture	0.048
			≥ Primary	Natural Gas	Mining	0.190
		Female	< Primary	Livestock	Agriculture	0.005
			≥ Primary	Commerce and Public Services	Service	0.026
	Others	Male	< Primary	Construction and Construction Services	Industrial	0.010
			≥ Primary	Railway Transport	Service	0.203
		Female	< Primary	Textiles and leather	Industrial	0.003
			≥ Primary	Commerce and Public Services	Service	0.047

Source: Authors' Computations.

Primary sectors, including agriculture, allied sectors, and mining, generate the highest labour income multipliers for most social groups in rural regions. In urban regions, the industrial and services sectors dominate. Table 14 summarises the results above by the broad labour income groups. It illustrates the sector with the highest labour income multiplier for each category.

Table 14 Largest Labour Income Multiplier Sector by Category

Category		Sector	Labour Income Multiplier
Disaggregation	Group		
Region	Rural	Agriculture	0.558
	Urban	Railway Transport	0.527
Social Group	ST	Forestry and Logging	0.118
	SC	Biomass (energy)	0.244
	OBC	Livestock	0.312
	Others	Commerce and Public Services	0.352
Gender	Male	Fishing & Aquaculture	0.849
	Female	Livestock	0.205

Source: Authors' Computations.

Table 15 Sectoral Change in Employment – Direct and Total Effects

Sector	Direct	Total
Paddy	2.001	2.361
Agriculture	0.622	0.901
Livestock	0.151	0.504
Forestry and Logging	0.025	0.258
Biomass (energy)	0.009	0.302
Fishing & Aquaculture	0.057	0.331
Coal and Lignite	0.013	0.118
Crude petroleum	0.001	0.029
Natural Gas	0.004	0.218
Iron Ore	0.008	0.195
Manganese Ore	0.000	0.139
Bauxite	0.004	0.186
Copper Ore	0.001	0.054
Other Metallic Minerals	0.007	0.229
Limestone	0.043	0.245
Other Non-Metallic Minerals	0.048	0.254
Food and Tobacco	0.044	0.728
Textiles and leather	0.136	0.443
Wood and Wood Products (Except Furniture)	0.197	0.448
Paper, Pulp, and Print	0.055	0.276
Rubber and Plastic Products	0.023	0.210
Petroleum Products - Combustible	0.003	0.084
Petroleum Products - Non-Combustible	0.004	0.086

Sector	Direct	Total
Fertilisers	0.005	0.163
Chemicals	0.017	0.170
Cement	0.019	0.213
Non-metallic Mineral prods.	0.107	0.322
Iron and Steel	0.013	0.175
Aluminium	0.005	0.183
Non-Ferrous Basic Metals (and Alloys)	0.002	0.189
Machinery	0.035	0.181
Transport Equipment	0.031	0.219
Industry NEC	0.061	0.187
Construction and Construction Services	0.151	0.418
Coal Electricity	0.016	0.264
Other Thermal Electricity	0.017	0.246
Hydro (Large) Electricity	0.024	0.247
Renewable Energy Sources Electricity	0.019	0.289
Nuclear Electricity	0.020	0.229
Railway Transport	0.042	0.298
Land transport	0.158	0.421
Water Transport	0.012	0.095
Air transport	0.009	0.253
Transport NEC	0.051	0.327
Commerce and Public Services	0.094	0.346

Source: Authors' Computations.

The data in Table 14 suggest that investment in the agriculture sector holds the most significant potential for increasing labour incomes in the rural region compared to investment in railway transport for the urban region. Of the social groups, only the Other Social Groups have a tertiary sector as its most significant multiplier; primary agriculture sectors provide the largest labour income multipliers for the marginalised social groups.

Employment Multipliers

The multipliers computed in the previous section describe the impact on sectors in rupees caused by an exogenous increase in spending in a specific sector. The methodology to compute these multipliers can be adapted to measure changes in employment numbers. For example, Table 15 shows the change in total employment in the economy, accounting for all SAM effects, due to an exogenous unit demand increase and the direct change in employment in the indicated sector resulting from a unit increase in the output of that sector. While the former will always be greater than the latter, the magnitude of the difference suggests a more significant potential for indirect job creation.

Sectors demonstrating the largest ratios of total to direct employment increase include the primary mining sectors, owing to their forward linkages with other labour-intensive manufacturing sectors, and the energy sectors of petroleum products and electricity, attributable to their pervasive use in all other sectors of the economy.

Figure 6 shows the increase in employment in the economy due to an exogenous demand unit increase for a given sector. However, the employment multiplier in isolation does not signify the average wages for each job created. For instance, making an additional investment in the Air Transport sector would result in fewer jobs, albeit with relatively higher wages, compared to the Agriculture sector, which would generate more jobs at a lower wage rate. Combining the information from Table 12 and Table 15 would give policymakers a sense of where high-paying jobs can be created and their distributional patterns.

Employment Linkages

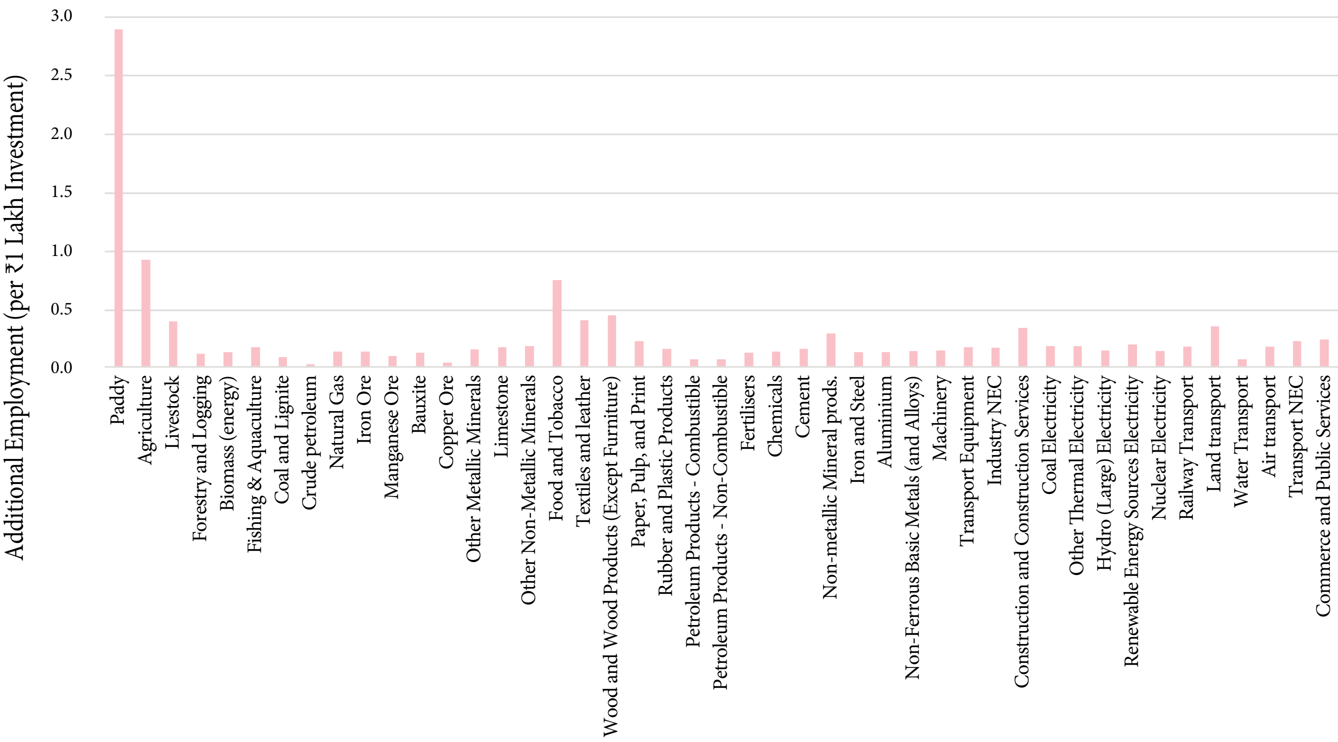
The hybrid employment multipliers measure the total jobs produced throughout the economy from a ₹1 lakh rise in final consumption. One can disaggregate the sectors where job creation is expected and assess the wage level per job. These illustrate the employment linkages in the economy through the necessity for additional job creation in other sectors, facilitating the growth of a specific sector. The production sectors have been grouped into seven broad sectors, and the proportion of employment generation by sector is depicted (Table 16).

Table 16 Employment Generation Linkages

Due to exogenous increase in spending in:	Share of Jobs Created in (%):						
	Agriculture	Mining	Manufacturing	Construction	Electricity	Transport	Services
Agriculture	88	0	3	1	0	1	7
Mining	39	16	13	2	0	7	23
Manufacturing	46	0	29	2	0	4	17
Construction	28	0	8	45	0	3	16
Electricity	38	1	10	6	10	5	30
Transport	26	0	6	2	0	44	22
Services	30	0	5	2	0	3	59

Source: Authors' Computations.

Figure 6 Labour Income Per Job Created



Source: Authors' Elaborations.

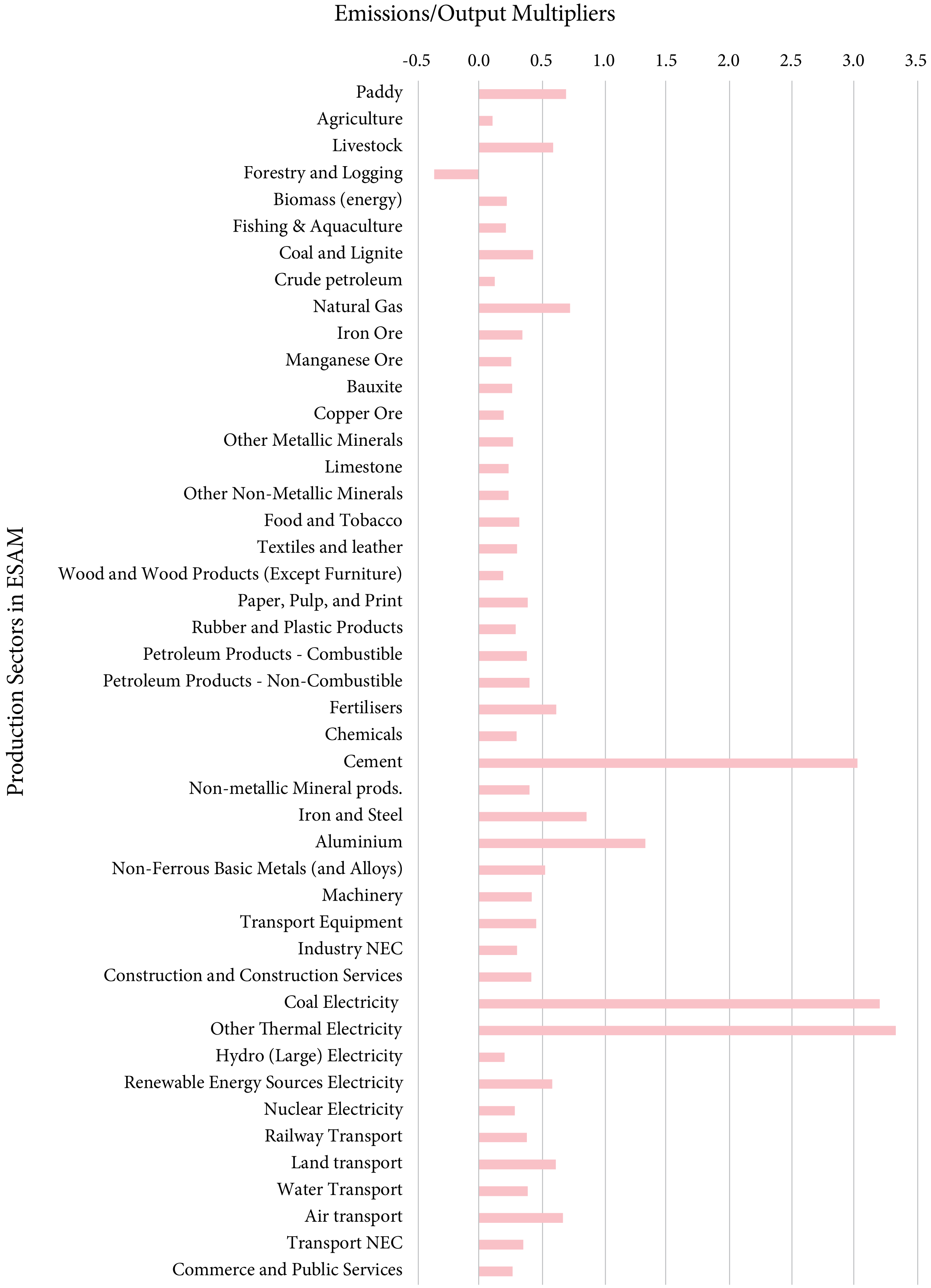
Cells with darker shading signify higher income per job. The mining and electricity sectors offer higher-paying jobs, whereas the agricultural sector provides lower wages. Additional investments in all sectors lead to increased employment in agriculture, mining, and services. For the electricity sector job creation is primarily driven by investments in the electricity sector itself.

Emissions Multipliers

A comparable analysis can be performed to calculate the hybrid emissions output multipliers. These are defined as the change in economy-wide CO_{2e} emissions resulting from an additional ₹1 lakh increase in the exogenous accounts of a given sector (measured in tonnes of CO_{2e} per ₹1 lakh). These can also be decomposed into own effects (change in emissions caused by sectors demanding more from other sectors), open loop (change in emissions from the increased transfer of incomes to households), and closed loop (change in emissions caused by households spending more from their increased earnings), as was the case with the standard multipliers. The detailed emissions output multipliers (N'), their decomposition, and standard output multipliers (N) are given for each sector in Appendix H. It is beneficial to highlight the sectors that contribute most to the overall increase in air emissions from an exogenous demand increase of ₹1 lakh: other thermal electricity, coal electricity, cement, aluminium, and paddy). These results can be compared to the ratio of hybrid emissions output multipliers to output multipliers (Figure 7). For each sector, this ratio represents how economy-wide emissions change relative to overall output changes (due to an additional ₹1 lakh exogenous demand in a given sector). In the case of positive ratios, a higher ratio indicates a more substantial increase in emissions relative to output.

Forestry & Logging is the sole sector with a negative total output-to-emissions multiplier ratio, a net absorber of greenhouse gas emissions. Thus, any increase in investments in this sector could decrease total emissions (although it should be emphasised that these are SAM multipliers, which do not consider certain economic limitations as CGE multipliers may, such as the availability of land to plant additional forests). Agriculture and Wood & Wood Products are other sectors with high output-to-emissions multiplier ratios. Additional investments in these sectors will result in relatively higher output increases compared to increases in CO2e emissions. Sectors like Cement and Aluminium have ratios below 1, indicating that increased investments in these sectors would lead to greater changes in emissions than economic output.

Figure 7 Ratio of Emissions to Output Multipliers



Source: Authors' Computations.

5.3 Computable General Equilibrium Modelling

Social Accounting Matrices are the underlying database for computable general equilibrium (CGE) modelling. CGE models combine real-world economic data with economic theory to predict the impacts of policy changes on the economy. These models account for the interlinkages between various economic agents (production sectors, government, and households), which can uncover unintended effects of economic shocks that partial equilibrium models (i.e., single-market models) may not reveal.

CGE models require two broad data inputs to feed into the equations of economic theory:

1. A Social Accounting Matrix (SAM) captures the circular flow of an economy. The CSEP Environmentally-extended SAM may be used for these types of models.
2. Elasticities are unitless parameters representing the responsiveness of one economic factor to another (such as supply and demand to a change in price). These are often found in literature and are computed based on real-world behaviours.

CGE modelling enables policymakers to comprehend the implications of various fiscal policy measures and the impacts of shocks on the economy.

6. Concluding Remarks

This study describes the methodology and materials used to construct an ESAM for India for 2019-20. This accounting matrix explains the inter-sectoral linkages between the production sectors, value-added, households and other institutions. The labour factor of production has been categorised based on region, social groups, occupation of the head of the family, education, and gender. The households' decile-wise disaggregation for four social groups across rural and urban regions can be used for experiments to examine the effects of policy changes on inequality. The impact of various taxation policies can also be examined using this ESAM. The environmental account has been employed to compute the emissions multipliers, aiding in understanding India's energy-intensive sectors. Such analysis provides insights into the sectors requiring urgent attention to expedite the energy transition's objectives. Some experiments conducted in this context identified the key sectors of the Indian economy that could assist in establishing strong employment linkages. The emissions multipliers were also studied using a separate experiment, which identified the industries that provide high output increases vis-à-vis corresponding increases in emissions.

In the subsequent studies, the CSEP-ESAM will serve as a database for CGE modelling, facilitating investigation into issues related to climate change, carbon border adjustment mechanisms, and the clean energy transition.

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8. Appendices

Appendix A: Schematic review of SAMs/ESAMs having Factors of production/Households' disaggregation

Sl. No.	Author	Year	Country	Base Year of the SAM	Total Sectors	Structure of Factors of Production	Structure of Households	Structure of Environmental Sectors
1	Carneiro & Junior	2018	Brazil	2010	18	Two factors-labour and capital	Seven classes of households are categorised as per income classes	NA
2	Gallardo & Mardones	2013	Chile	2008	34	Seven factors: labour was categorised as unskilled, semi-skilled and skilled, male and female.	Five categories of households classified by income quintile-wise	Seven air pollutants: respirable particulate material (PM10), carbon monoxide (CO), carbon dioxide (CO2), nitrogen oxides (NOx), volatile organic compounds (COV), sulphur oxides (SOx), and ammonia (NH3). Three categories of water pollutants: oils and fats, chlorides, and sulphates.
3	Xie	2000	China	1990	7	Two factors -labour and capital	1	Three types of pollution (wastewater, smog dust, and solid waste) and their corresponding pollution abatement sectors.
4	Banerjee et al.	2019	Guatemala	2010	24	Six factors, including four labour categories (non-salaried, salaried, and skill-wise -unskilled and skilled), capital, and land	Ten household classes - two rural and urban, and five quintiles for each region	Ten categories of water, seven types of forestry resources, two types of fishing resources, two types of mining resources, five categories of energy, three types of emissions (CO2, N2O, and CH4), one type of waste and one category of land

Sl. No.	Author	Year	Country	Base Year of the SAM	Total Sectors	Structure of Factors of Production	Structure of Households	Structure of Environmental Sectors
5	Sinha et al.	2007	India	1999-00	14	Four kinds of labourers: informal and formal labour corresponding to casual and regular workers, respectively. Four types of capital: Informal and formal capitalists, each corresponding to own-account workers and employers	Eight occupational categories of households, four each for Rural and Urban areas	NA
6	Saluja & Yadav	2006	India	2003-04	73	Two factors -labour and capital	Five household classes each, categorised by expenditure levels for rural and urban areas	NA
7	Ojha et al.	2009	India	2003-04	36	Three factors of production -labour, capital, and land	Nine household groups (5 for rural and 4 for urban) are classified as per occupational categories	NA
8	Pal et al.	2012	India	2003-04	85	Three factors of production -labour, capital, and land	Nine household groups (5 for rural and 4 for urban) are classified as per occupational categories	NA
9	Pradhan et al.	2013	India	2007-08	78	Five categories in total - three categories of labourers (unskilled, semi-skilled, and skilled), capital & land	for rural and 4 for urban) are classified as per occupational categories	NA

Sl. No.	Author	Year	Country	Base Year of the SAM	Total Sectors	Structure of Factors of Production	Structure of Households	Structure of Environmental Sectors
10	Pal et al.	2015	India	2006-07	35	Three factors of production -labour, capital, and land	Nine household groups (5 for rural and 4 for urban) are classified as per occupational categories	CO_2 equivalent (comprising of CO_2, N_2O, and CH_4) depletion and renewal of natural resources such as coal, crude oil, and land
11	Pal and Pohit	2014	India	2006-07	35	Three factors of production -labour, capital, and land	Nine household groups (5 for rural and 4 for urban) are classified as per occupational categories	CO_2 equivalent (comprising of CO_2, N_2O, and CH_4) depletion and renewal of natural resources such as coal, crude oil, and land
12	Pradhan et al.	2014	India	2005-06	41	Two factors of production -labour, and capital	Two Separate versions of SAMs: first, nine household groups (5 for rural and 4 for urban) classified as per occupational categories, and second, ten expenditure categories of households	NA
13	Pal and Bandarlage	2017	India	2007-08	78	49 categories in total, of which there are 48 types of labour categorised as per region (2), social class (4), education (3), and gender (2) and one separate capital	80 types of households -categorised as per their regions (2), social class (4), per-capita expenditure deciles (10)	NA
14	Venkatesh and Pal	2018	India	2012-13	140	Three factors of production (labour, capital, and land)	20 households' categories based on their region (2) and deciles of MPCE (10)	NA

Sl. No.	Author	Year	Country	Base Year of the SAM	Total Sectors	Structure of Factors of Production	Structure of Households	Structure of Environmental Sectors
15	Verma	2021	India	2007-08	33	Five categories in total: 3 categories of labourers (unskilled, semi-skilled, and skilled), capital & land	Nine household groups (5 for rural and 4 for urban) are classified as per occupational categories	Three environmental categories of air (CO2 equivalent consisting of N2O and CH4), water pollution (wastewater generation), and land degradation (dumping of industrial waste).
16	Pal et al.	2020	India	2017-18	111	13 categories of factors - 8 types of labour (4 categories of education and two categories of region), four types of capital (crop, live animal, mining, and other financial capital), and one category of land	15 in total, of which - Per capita expenditure quintiles (5) for all the 3 household categorisation (Rural farm households, rural non-farm households, and urban)	NA
17	Hartono and Reso-sudarmo	2008	Indonesia	2000	33	23 categories of fop: region (2), type of worker (2-formal & informal), occupational category (4), capital (7- Land, Housing, Rural Asset, Urban Asset, Domestic Private Capital, Government Asset and Foreign Capital)	Ten households: Agricultural Employee, Small Scale Farmer, Medium Scale Farmer, Large Scale Farmer, Rural Low Income, Rural Non-Labour, Rural High Income, Urban Low Income, Urban Non-Labour and Urban High Income	NA
18	Debowicz	2016	Iraq	2011	26	10 categories-6 categories of labour (2 classes of gender and three levels of skills), three forms of capital (agricultural, oil, and rest), and land	12 in total- region (2) and per-capita expenditure (1-female headed households and 5-quintiles of per-capita expenditure)	NA

Sl. No.	Author	Year	Country	Base Year of the SAM	Total Sectors	Structure of Factors of Production	Structure of Households	Structure of Environmental Sectors
19	Harun et al.	2012	Malaysia	2000	18	1	8 in total-Rural-Urban categorisation as per race-Malay, Chinese, Indian, and others	NA
20	Althumairi	2021	Saudi Arabia	2017	18	Four factors of production-Saudi and Non-Saudi and Capital and capital from oil	Six categories based on their incomes (low, lower middle, middle, upper middle-and high-income households and non-Saudi households)	NA
21	Kavese & Phiri	2020	South Africa	2015	10	Categorised by age (youth and adults), education (primary and tertiary), and by areas (urban and non-urban)	disaggregate households by race (African, white, Coloured, and Indian) and 12 income categories	NA
22	Chadha et al.	n.d.	India	2019	45	318 categories of labourers- Categorised labour by region, social groups, occupational category, education, and gender.	80 types of households-categorised as per their regions (2), social class (4), per-capita expenditure deciles (10)	Three environmental categories are air (CO2 equivalent consisting of N2O and CH4), water pollution (wastewater generation), and land degradation (dumping of industrial waste). The CSEP ESAM will be extended to include the energy flows from various sources, including coal, biomass, crude oil, natural gas, petroleum products, and electricity.

Source: Compiled from various sources, as mentioned in the table.

Developing an Environmentally-extended
Social Accounting Matrix for India 2019-20

Appendix B: Structure of Environmentally Extended Social Accounting Matrix for India-2019-20

	CSEP-ESAM Structure	Expenditures										Emissions		Renewal of Resources		Total Environmental Pollution		
												Damaging Substances (pollutants)		Depletable/Degraded Natural Resources		Environmental Theme		
		Production Account (45)	Labour FOP (318)	Capital FOP (1)	Households (80)	Private Corporate	Public Non-Departmental	Government	Indirect Taxes	Capital Account	Rest of the World (ROW)	GHGs	Waste Water Disposed	Renewal of Land	Reduction of Degraded Land	Greenhouse Effect	Water pollution	Land Pollution
Receipts	**Production Account (45)**	Input-Output Table (1,1)			Private consumption (1,4)			Govt. Consumption (1,7)		Investment (1,9)	Exports (1,10)	Emission of Pollutants from Production (1,11)	Waste Water Disposed (1,12)					
	Labour FOP (318)	Value added (VA) (2,1)									Net factor Income (2,10)							
	Capital FOP (1)	Value added (VA) (3,1)									Net factor Income (3,10)			Renewal of Land Capital (3,14)	Reduction of Degraded Land (3,15)			
	Households (80)		VA income (4,2)	Capital income (3,3)				Transfer Payments, interest on debt (4,7)			Net Current Transfers (4,10)	Emission of Pollutants from Consumption (4,11)	Waste Water Disposed by Households (4,12)					
	Private Corporate			Operating Profits (5,3)				Interest on Debt (5,7)										
	Public Non- Departmental			Operating Surplus (6,3)														
	Government			Income from Entrepreneurship (7,3)	Income and Wealth taxes (7,4)	Corporate Taxes (7,5)			Total indirect taxes (7,8)		Net Capital Transfer (7,10)							
	Indirect Taxes	Taxes on intermediate (8,1)			Taxes on purchases (8,4)			Taxes on purchases (8,7)		Taxes on investment goods (8,9)	Taxes on exports (8,10)							
	Capital Account			Depreciation (9,3)	Households Savings (9,4)	Corporate Savings (9,5)	Public non-departmental Savings (9,6)	Government savings (9,7)			Foreign Savings (9,10)							
	Rest of the World (ROW)	Imports (10,1)																

Developing an Environmentally-extended
Social Accounting Matrix for India 2019-20

CSEP-ESAM Structure			**Expenditures**										**Emissions**		**Renewal of Resources**		**Total Environmental Pollution**		
													Damaging Substances (pollutants)		**Depletable/Degraded Natural Resources**		**Environmental Theme**		
			Production Account (45)	**Labour FOP (318)**	**Capital FOP (1)**	**Households (80)**	**Private Corporate**	**Public Non-Departmental**	**Government**	**Indirect Taxes**	**Capital Account**	**Rest of the World (ROW)**	**GHGs**	**Waste Water Disposed**	**Renewal of Land**	**Reduction of Degraded Land**	**Greenhouse Effect**	**Water pollution**	**Land Pollution**
Absorption of Pollution	**Damaging Substances (pollutants)**	GHGs	Absorption of Sub-stances in Production (11,1)			Absorption of Sub-stances in Consump-tion (11,4)									Removal of Sub-stances (11,14)		Accumu-lation of Substances (11,16)	Amount of Waste-water Gener-ated (11,17)	Extent of Land Degrada-tion (11,18)
		Waste Water Disposed	Treatment of Waste Water through Industries (12,1)			Treatment of Waste Water through Govern-ment Institutions (12,4)													
Depletion of Resources	**Depletable/ Degraded Natural Resources**	Depletion of Land			Depletion of Land through Conservation (14,3)								Emission from Land use Change (14,11)						
		Degradation of Land			Degradation of Land (15,3)												Reduction of Land's Productivity (15,16)		
Total Environmental Pollution	**Environmental Theme**	Greenhouse Effect			Accumulation of GHGs (16,3)														
		Water pollution			Amount of Wastewater Generated (17,3)														
		Land Pollution			Extent of Land Degradation (18,3)														

Appendix C: Concordance between CSEP-ESAM and CSEP-IOT Production Sectors

#	CSEP ESAM	#	CSEP IOT
1	Paddy	1	Paddy
2	Agriculture	2	Wheat
		3	Jowar
		4	Bajra
		5	Maize
		6	Gram
		7	Pulses
		8	Sugarcane
		9	Groundnut
		10	Coconut
		11	Other oilseeds
		12	Jute
		13	Cotton
		14	Tea
		15	Coffee
		16	Rubber
		17	Tobacco
		18	Fruits
		19	Vegetables
		20	Other crops
3	Livestock	21	Milk and milk products
		22	Poultry & Eggs
		23	Other livestock products
		24	Animal Services
4	Forestry and Logging	25	Forestry and Logging
5	Biomass (energy)	-	New sector
6	Fishing & Aquaculture	26	Fishing & Aquaculture
7	Coal and Lignite	27	Coal and Lignite
8	Crude petroleum	28	Crude petroleum
9	Natural Gas	29	Natural Gas
10	Iron ore	30	Iron ore
11	Manganese ore	31	Manganese ore
12	Bauxite	32	Bauxite
13	Copper ore	33	Copper ore
14	Other metallic minerals	34	Other Metallic minerals
15	Limestone	35	Lime stone
16	Other non-metallic minerals	36	Mica
		37	Other non-metallic minerals

#	CSEP ESAM	#	CSEP IOT
17	Food and tobacco	38	Sugar
		39	Khandsari, boora
		40	Hydrogenated oil (vanaspati)
		41	Edible oils other than vanaspati
		42	Tea and coffee processing
		43	Miscellaneous food products
		44	Grain Mill products, starch and starch products
		45	Beverages
		46	Tobacco Products
18	Textiles and leather	47	Khadi, cotton textiles(handlooms)
		48	Cotton textiles
		49	Woollen textiles
		50	Silk textiles
		51	Art silk, synthetic fibre textiles
		52	Jute, hemp, mesta textiles
		53	Carpet weaving
		54	Miscellaneous textile products
		55	Ready-made garments
		60	Leather footwear
		61	Leather and leather products
19	Wood and wood products except furniture	56	Wood and wood products except furniture
20	Paper, pulp and print	57	Paper, Paper products and newsprint
		58	Publishing, printing and allied activities
21	Rubber and plastic products	62	Rubber products
		63	Plastic products
22	Petroleum products (combustible)	64	Petroleum products
23	Petroleum products (non-combustible)		
24	Fertilisers	68	Fertilizers
25	Chemicals	65	Coal tar products
		66	Inorganic heavy chemicals
		67	Organic heavy chemicals
		69	Pesticides
		70	Paints, varnishes and lacquers
		71	Soaps, cosmetics & glycerine
		72	Synthetic fibres, resin
		73	Other chemicals
		74	Drugs and medicine
26	Cement	76	Cement
27	Non-metallic mineral products	75	Structural clay products
		77	Other non-metallic mineral prods.

#	CSEP ESAM	#	CSEP IOT
28	Iron and Steel	78	Iron, steel and ferroalloys
		79	Iron and steel casting & forging
		80	Iron and steel foundries
29	Aluminium	81	Non-ferrous basic metals (including alloys)
30	Non-ferrous basic metals (including alloys, excluding aluminium)		
31	Machinery and equipment	82	Hand tools, hardware
		83	Miscellaneous metal products
		84	Tractors and agri. implements
		85	Industrial machinery (F & T)
		86	Industrial machinery(others)
		87	Machine tools
		88	Other non-electrical machinery
		89	Electrical industrial Machinery
		90	Electrical wires & cables
		91	Batteries
		92	Other electrical Machinery
		93	Electrical appliances
		94	Electronic equipment(incl.TV)
		95	Watches and clocks
		96	Communication equipment
		104	Medical, precision &optical instruments
32	Transport equipment	97	Ships and boats
		98	Rail equipment
		99	Motor vehicles
		100	Motorcycles and scooters
		101	Bicycles, cycle-rickshaw
		102	Other transport equipment
		103	Aircraft & spacecraft
33	Industry NEC	59	Furniture & Fixtures
		105	Gems & jewellery
		106	Miscellaneous manufacturing
34	Construction and construction services	107	Construction and construction services
35	Coal electricity	108	Electricity
36	Other thermal electricity		
37	Hydro (large) electricity		
38	Renewable energy sources electricity		
39	Nuclear electricity		
40	Railway transport	110	Railway Transport
41	Land transport	111	Land transport
42	Water transport	112	Water Transport
43	Air transport	113	Air transport

#	CSEP ESAM	#	CSEP IOT
44	Transport NEC	114	Supportive and Auxiliary transport activities
		115	Storage and warehousing
45	Commerce and public services	109	Water supply
		116	Communication services
		117	Trade
		118	Hotels & Restaurant
		119	Financial services
		120	Insurance services
		121	Ownership of dwellings
		122	Education and research
		123	Medical and Health
		124	Legal services
		125	Computer related services
		126	Other Business services
		127	Real estate services
		128	Renting of machinery & equipment
		129	Community, social and personal services
		130	Other services
		131	Public administration and defence

Source: Authors' Elaboration.

Appendix D: Concordance between NAS PFCE Sectors and CSEP ESAM

NAS PFCE Sector	CSEP ESAM Sector(s)
Bread, cereals and pulses	Paddy Agriculture Food and tobacco
Meat	Livestock Food and tobacco
Fish and seafood	Fishing & aquaculture Food and tobacco
Milk and milk products	Livestock Food and tobacco
Eggs	Livestock
Oils and fats	Food and tobacco
Fruit	Food and tobacco
Vegetables	Food and tobacco
Sugar, jam, honey, chocolate and confectionery	Food and tobacco
Food products NEC	Food and tobacco
Coffee, tea and cocoa	Food and tobacco
Mineral waters, soft drinks, fruit and vegetable juices	Food and tobacco
Alcoholic beverages	Food and tobacco
Tobacco	Food and tobacco

NAS PFCE Sector	CSEP ESAM Sector(s)
Narcotics	Food and tobacco
Clothing	Textiles and leather
Footwear	Textiles and leather
Gross rentals for housing	Commerce and public services
Water supply and miscellaneous services relating to the dwelling	Commerce and public services
Electricity	Coal electricity Other thermal electricity Hydro (large) electricity Renewable energy sources electricity Nuclear electricity
Gas	Combustible petroleum products
Liquid fuels	Combustible petroleum products Non-combustible petroleum products
Solid fuels	Non-combustible petroleum products Forestry and logging Coal and lignite
Furniture and furnishing, carpets and other floor coverings	Industry NEC Textiles and leather
Household textiles	Textiles and leather
Household appliances	Machinery and equipment
Glassware, tableware and household utensils	Non-metallic mineral products Rubber and plastic
Tools and equipment for house & garden	Machinery and equipment
Goods and services for routine household maintenance	Rubber and plastic Chemicals
Health	Commerce and public services
Purchase of vehicles	Transport equipment
Operation of personal transport equipment	Combustible petroleum products Transport equipment
Transport services	Railway transport Land transport Water transport Air transport Transport NEC
Communication	Commerce and public services
Audio-visual, photographic and information processing equipment	Machinery and equipment
Other major durables for recreation and culture	Industry NEC
Other recreational items and equipment, gardens and pets	Industry NEC
Recreational and cultural services	Commerce and public services
Newspapers, books and stationery	Paper, pulp, and print
Education	Commerce and public services
Restaurants and hotels	Commerce and public services

NAS PFCE Sector	CSEP ESAM Sector(s)
Personal care	Commerce and public services Machinery and equipment Chemicals
Personal effects NEC	Industry NEC
Insurance	Commerce and public services
Financial services other than insurance	Commerce and public services
Other services NEC	Commerce and public services

Source: Authors' Representation.

Table 17 RAS Set-up in an IOT Framework

Sectors	X	Y	Z	Total intermediate industry transactions	Total final demand =PFCE +GFCE +GCF +Exports −Imports	Output
X	$A_{X;X}$	$A_{X;Y}$	$A_{X;Z}$	$II_X = \sum_m A_{X;m}$	TF_X	$O_X = II_X + TF_X$
Y	$A_{Y;X}$	$A_{Y;Y}$	$A_{Y;Z}$	$II_Y = \sum_m A_{Y;m}$	TF_Y	$O_Y = II_Y + TF_Y$
Z	$A_{Z;X}$	$A_{Z;Y}$	$A_{Z;Z}$	$II_Z = \sum_m A_{Z;m}$	TF_Z	$O_Z = II_Z + TF_Z$
Inputs	$in_X = \sum_n A_{n;X}$	$in_Y = \sum_n A_{n;Y}$	$in_Z = \sum_n A_{n;Z}$			
NIT +GVA	G_X	G_Y	G_Z			
Output	$O_X = in_X + G_X$	$O_Y = in_Y + G_Y$	$O_Z = in_Z + G_Z$			

Source: Authors' Representation of a Standard IOT model.

Appendix E: RAS Methodology

The RAS technique is typically used to balance matrices or determine missing or unknown values in the input-output table. It is an iterative process that adjusts rows and columns of a matrix to predefined totals, with the magnitude of the adjustments reducing until the table is balanced. In the input-output context, a balanced table is one where a sector's row and column sums are equal.

For the CSEP-ESAM, sectoral macroeconomic data for 2019-20 (sources and estimates are detailed in earlier sections) were used to construct the IOT 2019-20. As illustrated in the IOT structure in Table 1, all the data, barring the inter-industry production accounts transactions, are available. The RAS has been used on the IOT 2015-16, with the predefined totals set as the sectoral macroeconomic data, to estimate the inter-industry transactions for 2019-20.

The setup for using the RAS method is represented in Table 17, which shows a 3-sector IOT model (sectors X, Y, and Z). The outputs of each sector are represented by $\boldsymbol{O}_{X,Y,Z}$; the sectoral sums of final user sectors (household expenditure, government expenditure, gross capital formation, and net exports) are represented by $\boldsymbol{TF}_{X,Y,Z}$; the sectoral sums of NIT and GVA are represented by $\boldsymbol{G}_{X,Y,Z}$; the sums of inter-industry transactions are represented by $\boldsymbol{II}_{X,Y,Z}$; the sums of inputs are represented by $\boldsymbol{in}_{X,Y,Z}$; and the intermediate transactions are represented by $\boldsymbol{A}_{X,Y,Z\,;\,X,Y,Z}$. also shows how the summation of a sector's row and column in the IOT gives the sector's total output (i.e., the sum of a sector's row is the same as the sum of the sector's column).

The RAS technique requires determining target column and row totals for IOT 2019-20. These targets are derived from the known macroeconomic data on sectoral output, NITs, GVA, and total final demand. The sectoral target column sum refers to the total inputs (i.e., $\boldsymbol{O} - \boldsymbol{G}$), and the sectoral target row sum refers to the total intermediate industry transactions (i.e., $\boldsymbol{O} - \boldsymbol{T}$). The RAS computations are based on the target values.

The methodology of the RAS estimation is highlighted below using a 3-sector example. Table 18 shows the original table to which the RAS method will be applied, along with the target row and column sums. It's worth noting that these sums do not necessarily need to be equal, as is the case with updating IOT 2015-16.

The first RAS step is proportionally adjusting each row entry so the row totals match the targets (Table 19). In this case, the row totals equal the targets, but the column totals do not. The second step is to proportionally increase or decrease each entry of all

Table 18 RAS Method Example – Original Table

Sector	X	Y	Z	Total	Target
X	600	450	950	2000	2200
Y	750	1000	1250	3000	3450
Z	650	1550	1800	4000	4800
Total	2000	3000	4000	–	–
Target	2200	3450	4800	–	–

Source: Authors' Elaboration.

Table 19 RAS Method Example – Row adjustment

Sector	X	Y	Z	Total	Target
X	660	495	1045	2000	2200
Y	863	1150	1438	3450	3450
Z	780	1860	2160	4800	4800
Total	2303	3505	4643	–	–
Target	2200	3450	4800	–	–

Source: Authors' Elaboration.

Table 20 RAS Method Example – Column adjustment

Sector	X	Y	Z	Total	Target
X	631	487	1080	2198	2200
Y	824	1132	1486	3442	3450
Z	745	1831	2233	4809	4800
Total	2200	3450	4800	–	–
Target	2200	3450	4800	–	–

Source: Authors' Elaboration.

rows so that its sum reaches the target sum (Table 20). After this step, the column totals match the targets, while the row totals do not. These two steps are repeated until the target sums for both the columns and the rows are reached.

The targets are attained after iterative row and column adjustments (Table 21).

The new matrix's technical coefficients (i.e., the ratio of an input to a sector to that sector's output) are similar to the original matrix's coefficients, as seen in Table 22. This method was used on the 45 production sectors of IOT 2015-16 to reach the IOT 2019-20 levels.

Table 21 RAS Method Example – Final Solution

Sector	X	Y	Z	Total	Target
X	631	488	1081	2200	2200
Y	826	1135	1490	3450	3450
Z	743	1828	2229	4800	4800
Total	2200	3450	4800	–	–
Target	2200	3450	4800	–	–

Source: Authors' Elaboration.

Table 22 RAS Method Example – Comparing Technical Coefficients

Sector	X		Y		Z	
	Original	New	Original	New	Original	New
X	0.30	0.29	0.15	0.14	0.24	0.23
Y	0.38	0.38	0.33	0.33	0.31	0.31
Z	0.33	0.34	0.52	0.53	0.45	0.46

Source: Authors' Elaboration.

Appendix F: Concordance between CSEP-ESAM and NIC sectors at 5-digit level

S. No.	CSEP-ESAM Sectors	NIC 5-digit sector
1	Paddy	01121, 01122, 01123, 01124
2	Agriculture	01111, 01112, 01113, 01114, 01140, 01116, 01261, 01115, 01117, 01118, 01119, 01162, 01161, 01271, 01272, 01273, 01279, 1291, 01292, 01293, 01299, 01150, 01221, 01222, 01223, 01224, 01225, 01229, 01231, 01232, 01233, 01239, 01241, 01242, 01243, 01249, 01251, 01252, 01259, 01262, 01261, 01269, 01131, 01132, 01133, 01134, 01135, 01136, 01137, 01139, 01279, 01611, 01612, 01619, 01620, 01631, 01632, 01633, 01639, 01640, 01700, 01191, 01192, 01193, 01199, 01281, 01282, 01283, 01284, 01285, 01286, 01287, 01191, 01210, 01169, 01302
3	Livestock	01411, 01412, 01413, 01420, 01430, 01441, 01442, 01443, 01450, 01461, 01462, 01463, 01491, 01492, 01493, 01499, 01500
4	Forestry and Logging	02101, 02102, 02109, 02209, 02301, 02302, 02303, 02309, 02401, 02402, 01301, 02202
5	Biomass (energy)	02201, 02203

S. No.	CSEP-ESAM Sectors	NIC 5-digit sector
6	Fishing & Aquaculture	03111/03113, 03211/03214, 03215, 03219, 03221/03223, 03229, 03121, 03122
7	Coal and Lignite	05101/05103, 05109, 05201/05203, 05209, Part of 09900
8	Crude petroleum	06101/06102, 09101, 09102
9	Natural Gas	06201/06202, 09103, 09104
10	Iron ore	7100, Part of 09900
11	Manganese ore	7293, Part of 09900
12	Bauxite	7292, Part of 09900
13	Copper ore	7291, Part of 09900
14	Other metallic minerals	07294/07296, 07299, Part of 09900
15	Limestone	08107, Part of 09900
16	Other non-metallic minerals	07210, 08101/08109 (except 08107), 08911/08915, 08919, 08920, 08931, 08932, 08991/08999, Part of 09900
17	Food and tobacco	10721/10729, 10401/10407, 10791/10792, 10101/10109, 10201/10207, 10209, 10301/10309, 10409, 10501/10505, 10509, 10611/10619, 10621/10626, 10629, 10711/10712, 10719, 10731/10736, 10739, 10740, 10750, 10793/10799, 10801/10803, 10809, 11011/11012, 11019, 11020, 11031/11033, 11039, 11041/11045, 11049, 12001/12009
18	Textiles and leather	13111/13114, 13119, 13121/13124, 13129, 13131/13136, 13139, 13911/13913, 13919, 13921/13926, 13929, 13931/13935, 13939, 13941/13946, 13949, 13991/13999, 14101/14105, 14109, 14201/14202, 14209, 14301, 14309, 15111/15116, 15119, 15121/15123, 15129, 15201/15202, 15209
19	Wood and wood products except furniture	16101/16103, 16109, 16211/16213, 16219, 16221/16222, 16229, 16231/16233, 16239, 16291/16297, 16299
20	Paper, pulp and print	17011/17017, 17019, 17021/17024, 17029, 17091/17097, 17099, 18111/18115, 18119, 18121/18122, 18129, 18200, 58111/58113, 58121, 58122, 58131, 58132, 58191, 58199
21	Rubber and plastic products	22111/22113, 22119, 22191/22194, 22199, 22201/22209
22	Petroleum products-Combustible	19201, 19203, 19204, 35201, 35202
23	Petroleum Products-Non-Combustible	19202, 19209
24	Fertilisers	20121, 20123, 20129, 20122
25	Chemicals	20111/20119, 20131/20133, 20211/20213, 20219, 20221/20224, 20229, 20231/20239, 20291/20297, 20299, 20301/20302, 20303(correct), 20304, 21001/21006, 21009, 19101, 19109 (Coal Tar Products)
26	Cement	23941, 23942, 23949
27	Non-metallic mineral products	23101/23107, 23109, 23911/23913, 23919, 23921/23923, 23929, 23931/23935, 23939, 23943/23945, 23951/23956, 23959, 23960, 23991/23994, 23999
28	Iron and Steel	24101/24109, 24311, 24319,
29	Aluminium	24202, Part of 24320

S. No.	CSEP-ESAM Sectors	NIC 5-digit sector
30	Non-ferrous basic metals (including alloys, excluding aluminium)	24201, 24203, 24204, 24205, 24209, Part of 24320
31	Machinery	25111, 25112, 25113, 25119, 25121/25123, 25129, 25131/25133, 25139, 25200, 25910, 25920, 25931/25934, 25939, 25991/25996, 25999, 28110, 28120, 28131, 28132, 28140, 28150, 28170, 28180, 28211/28213, 28219, 28221/28223, 28229, 28230, 28241/28246, 28249, 28251/28256, 28259, 28261/28266, 28269, 28291/28293, 28299, 26101/26109 (except 26108), 26201/26209 (except 26206/26208), 26301/26309 (except 26306/26308), 26401/26409 (except 26407/26408), 26511/26519 (except 26518), 26521/26529 (except 26524/26528), 26600, 26700, 26800, 27101/27104, 27201/27202, 27310, 27320, 27331, 27339, 27400, 27501/27504, 27509, 27900, 28161/28162, 28170, 28180, 28191/28195, 28199, 33111/33114, 33119, 33121/33127, 33129, 33131/33133, 33140, 33190, 33200
32	Transport equipment	29101/29104, 29109, 29201/29202, 29209, 29301/29304, 30111/30115, 30120, 30201/30206, 30301/30305, 30911/30913, 30921/30923, 30991, 30999, 33150, 45200
33	Industry NEC	32111/32114, 32119, 32120, 32201/32204, 32209, 32300, 32401/32405, 32409, 32501/32507, 32509, 32901/32904, 32909, 27101/27104, 27201/27202, 27310, 27320, 27331/27339, 27400, 27501/27504, 27509, 27900, 26101/26107, 26109, 31001/31005, 31009,
34	Construction and construction services	41001/41003, 42101/42103, 42201/42206, 42209, 42901/42904, 42909, 43110, 43121/43123, 43129, 43211/43214, 43219, 43221/43222, 43229, 43291/43292, 43299, 43301/43303, 43309, 43900
35	Coal electricity	35102, Part of (35107 & 35109)
36	Other thermal electricity	35103, Part of (35107 & 35109)
37	Hydro (large) electricity	35101, Part of (35107 & 35109)
38	Renewable energy sources electricity	35105, 35106, Part of (35107 & 35109)
39	Nuclear electricity	35104, Part of (35107 & 35109)
40	Railway transport	49110, 49120
41	Land transport	49211/49213, 49219, 49221/49226, 49229, 49231/49232, 49300
42	Water transport	50111/50113, 50119, 50120, 50211/50213, 50219, 50220
43	Air transport	51101/51102, 51109, 51201/51202
44	Transport NEC	52101/52102, 52109, 52211, 52212, 52213, 52219, 52220, 52231, 52232, 52241/52243, 52291/52294

S. No.	CSEP-ESAM Sectors	NIC 5-digit sector
45	Commerce and public services	53100, 53200, 58201/58203, 59111/59113, 59121/59123, 59131/59133, 59141/59142, 59201/59202, 60100, 61101/61104, 61201/61202, 61209, 61301, 61309, 61900, 45101,45102, 45300, 45401/45403, 46101/46103, 46109, 47110, 47190, 47211/47215, 47219, 47221, 47222, 47230, 47300, 47411/47414, 47420, 47510, 47521/47522, 47523, 47531, 47532, 47591/47595, 47599, 47611, 47612, 47613, 47620, 47630, 47711/47714, 47721/47722, 47731/47739, 47740, 47810, 47820, 47890, 47911, 47912, 47990, 55101, 55102, 55109, 55200, 55901, 55902, 56101/56104, 56210, 56291/56292, 56301/56304, 64110, 64191/64192, 64199, 64200, 64300, 64910, 64920, 64990, 65110, 65120, 65020, 65300, 66110, 66120, 66190, 66210, 66220, 66290, 66301, 66302, 66309, 68100, 85101/85104, 85109, 85211/85213, 85221/85223, 85301/85307, 85410, 85420, 85491/85494, 85499, 85500, 72100, 72200, 86100, 86201/86202, 86901/86906, 86909, 87100, 87200, 87300, 87900, 69100, 69201/69202, 70100, 70200, 71100, 71200, 73100, 73200, 74101/74103, 74109, 74201/74204, 74209, 74901/74904, 74909, 68100, 68200, 62011/62013, 62020, 62091, 62092, 62099, 63111/63114, 63119, 63121, 63122, 63910, 63991/63992, 63999, 75000, 77100, 77210, 77220, 77291/77294, 77299, 77301/77309, 77400, 78100, 78200, 78300, 79110, 79120, 79900, 80100, 80200, 80300, 81210, 81291, 81292, 81299, 81300, 82110, 82191, 82192, 82199, 82200, 82300, 82910, 82920, 82990, 88100, 88900, 90001/90006, 90009, 91010, 91020, 92001, 92002, 92009, 93110, 93120, 93190, 93210, 93290, 94110, 94120, 94200, 94910, 94920, 94990, 95111, 95112, 95120, 95210/95222, 95230, 95240, 95291/95295, 95299, 96010, 96020, 96030, 96091/96092, 96093/96098, 97000, 98100, 98200, 99000, 30400, 36000, 38110, 38120, 38210, 38221, 38222, 38300, 39000, 46201/46209, 35301/35303, 81100, 84111/84112, 84119, 84121, 84122, 84129, 84130, 84210, 84220, 84230, 84300, 91030, 37001, 37002, 37003, 47640, 60200, 95210

Source: Authors' Representation.

Appendix G: Labour Income Coefficients and Multipliers

Sector	Labour Income Coefficients (Per ₹ Lakh Output)	Labour Income Multipliers (Per ₹ Lakh Final Demand)
Paddy	0.283	0.844
Agriculture	0.484	0.923
Livestock	0.427	0.952
Forestry and Logging	0.419	0.808
Biomass (energy)	0.457	0.917
Fishing & Aquaculture	0.477	0.933
Coal and Lignite	0.092	0.282
Crude petroleum	0.025	0.077
Natural Gas	0.199	0.603

Sector	Labour Income Coefficients (Per ₹ Lakh Output)	Labour Income Multipliers (Per ₹ Lakh Final Demand)
Iron Ore	0.127	0.484
Manganese Ore	0.068	0.335
Bauxite	0.103	0.474
Copper Ore	0.027	0.135
Other Metallic Minerals	0.120	0.552
Limestone	0.187	0.549
Other Non-Metallic Minerals	0.188	0.563
Food and Tobacco	0.056	0.784
Textiles and leather	0.136	0.665
Wood and Wood Products (Except Furniture)	0.097	0.527
Paper, Pulp, and Print	0.100	0.529
Rubber and Plastic Products	0.071	0.460
Petroleum Products - Combustible	0.010	0.193
Petroleum Products - Non-Combustible	0.010	0.195
Fertilisers	0.037	0.361
Chemicals	0.062	0.353
Cement	0.090	0.483
Non-metallic Mineral prods.	0.087	0.506
Iron and Steel	0.053	0.405
Aluminium	0.067	0.452
Non-Ferrous Basic Metals (and Alloys)	0.031	0.432
Machinery	0.073	0.379
Transport Equipment	0.070	0.463
Industry NEC	0.056	0.307
Construction and Construction Services	0.274	0.806
Coal Electricity	0.127	0.646
Other Thermal Electricity	0.058	0.549
Hydro (Large) Electricity	0.307	0.689
Renewable Energy Sources Electricity	0.115	0.703
Nuclear Electricity	0.230	0.594
Railway Transport	0.350	0.835
Land transport	0.229	0.746
Water Transport	0.075	0.242
Air transport	0.077	0.616
Transport NEC	0.229	0.799
Commerce and Public Services	0.363	0.824

Source: Authors' Computations.

Appendix H: Emissions Multipliers

Sectors	Emissions Output Multipliers				Output Multiplier		
	N_1'	N_2'	N_3'	N'	N	N/N'	N'/N
Paddy	3.44	0.12	0.91	4.46	6.38	1.4	0.7
Agriculture	-0.45	0.13	0.98	0.66	5.98	9.0	0.1
Livestock	2.58	0.13	1.01	3.72	6.23	1.7	0.6
Forestry and Logging	-2.88	0.11	0.86	-1.91	5.35	-2.8	-0.4
Biomass (energy)	0.25	0.13	0.97	1.35	5.98	4.4	0.2
Fishing & Aquaculture	0.19	0.13	0.98	1.31	5.97	4.6	0.2
Coal and Lignite	0.93	0.05	0.35	1.32	3.04	2.3	0.4
Crude petroleum	0.09	0.01	0.10	0.20	1.56	7.7	0.1
Natural Gas	3.11	0.10	0.76	3.97	5.43	1.4	0.7
Iron Ore	1.08	0.08	0.60	1.76	5.02	2.9	0.4
Manganese Ore	0.47	0.05	0.40	0.92	3.52	3.8	0.3
Bauxite	0.58	0.07	0.57	1.22	4.56	3.7	0.3
Copper Ore	0.22	0.02	0.16	0.40	1.98	5.0	0.2
Other Metallic Minerals	0.69	0.09	0.67	1.45	5.26	3.6	0.3
Limestone	0.39	0.09	0.70	1.18	4.95	4.2	0.2
Other Non-Metallic Minerals	0.40	0.09	0.71	1.20	5.00	4.2	0.2
Food and Tobacco	1.13	0.11	0.86	2.10	6.44	3.1	0.3
Textiles and leather	0.93	0.10	0.73	1.75	5.73	3.3	0.3
Wood and Wood Products (Except Furniture)	0.31	0.08	0.65	1.04	5.30	5.1	0.2
Paper, Pulp, and Print	1.32	0.08	0.60	2.00	5.09	2.5	0.4
Rubber and Plastic Products	0.74	0.07	0.52	1.34	4.52	3.4	0.3
Petroleum Products - Combustible	0.93	0.03	0.24	1.20	3.12	2.6	0.4
Petroleum Products - Non-Combustible	1.00	0.03	0.25	1.28	3.14	2.5	0.4
Fertilisers	2.12	0.06	0.44	2.62	4.22	1.6	0.6
Chemicals	0.71	0.06	0.45	1.22	4.03	3.3	0.3
Cement	14.67	0.08	0.62	15.36	5.06	0.3	3.0
Non-metallic Mineral prods.	1.37	0.08	0.63	2.08	5.12	2.5	0.4
Iron and Steel	3.34	0.06	0.48	3.88	4.49	1.2	0.9
Aluminium	5.97	0.07	0.54	6.58	4.93	0.7	1.3
Non-Ferrous Basic Metals (and Alloys)	1.95	0.06	0.49	2.51	4.70	1.9	0.5
Machinery	1.20	0.06	0.43	1.68	3.96	2.3	0.4
Transport Equipment	1.62	0.07	0.56	2.25	4.87	2.2	0.5
Industry NEC	0.65	0.04	0.34	1.03	3.38	3.3	0.3
Construction and Construction Services	1.59	0.11	0.82	2.51	5.95	2.4	0.4
Coal Electricity	17.43	0.10	0.74	18.26	5.69	0.3	3.2
Other Thermal Electricity	17.57	0.08	0.62	18.27	5.47	0.3	3.3

Sectors	Emissions Output Multipliers				Output Multiplier		
	N_1'	N_2'	N_3'	N'	N	N/N'	N'/N
Hydro (Large) Electricity	0.16	0.11	0.85	1.12	5.47	4.9	0.2
Renewable Energy Sources Electricity	2.62	0.10	0.79	3.52	5.96	1.7	0.6
Nuclear Electricity	0.70	0.10	0.73	1.52	5.28	3.5	0.3
Railway Transport	1.27	0.12	0.89	2.27	5.88	2.6	0.4
Land transport	2.64	0.10	0.80	3.54	5.73	1.6	0.6
Water Transport	0.73	0.03	0.26	1.02	2.60	2.5	0.4
Air transport	2.83	0.09	0.66	3.58	5.32	1.5	0.7
Transport NEC	1.21	0.11	0.85	2.17	6.07	2.8	0.4
Commerce and Public Services	0.56	0.11	0.87	1.54	5.68	3.7	0.3

Source: Authors' Computations.

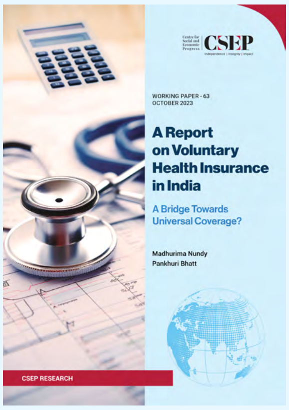
About the authors

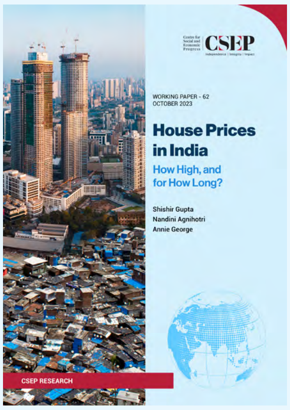
Rajesh Chadha is a Senior Fellow at CSEP. He was formerly a Professor and Research Director at the National Council of Applied Economic Research (NCAER) and, before that, an Associate Professor of Economics at Hindu College, University of Delhi. Rajesh has worked extensively on the issues of international trade, FDI and non-fuel minerals & mining in India. He has been a Visiting Scholar at the Universities of Michigan, Melbourne, and Monash and a Visiting Faculty at many prestigious academic and research institutes in India. Rajesh was nominated as GTAP Research Fellow (2004-2007) by the Global Trade Analysis Project, Purdue University. He received his PhD in Economics from the Indian Institute of Technology, New Delhi.

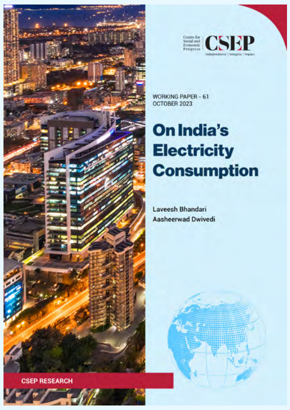
Ganesh Sivamani is a Research Associate on the Non-Fuel Minerals and Mining research project. He has worked on various issues pertaining to this sector including, the auctions process, securing India's critical minerals needs, international good practices, and economic linkages of the mining sector through the construction of Input-Output Transactions Tables and a Social Accounting Matrix. His other research interests include the impacts of climate change and its mitigation measures, with a focus on India's clean energy transition. Ganesh holds a Master of Engineering degree from the University of Cambridge, with a specialisation in Energy, Sustainability, and the Environment.

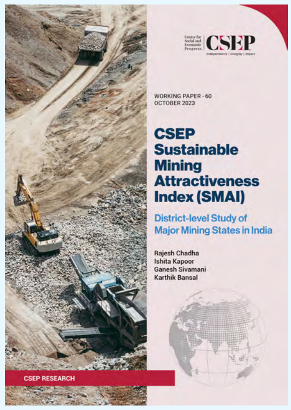
Rajat Verma is an Associate Fellow at CSEP. He specialises in Input-Output/SAM Modelling and ecological taxation. He recently published a book titled "Fiscal Control of Pollution: Application of Ecotaxes in India", wherein he critically examined the theoretical and pragmatic application of optimal rates of ecotaxation and their distributional impacts on households in India. In addition to his interest in Public Finance, he has also published innovative research papers on environmental taxes and international trade. He received PhD in Economics with a specialisation in Environmental Economics from the Institute for Social and Economic Change (ISEC), Bangalore which is affiliated with the University of Mysore.

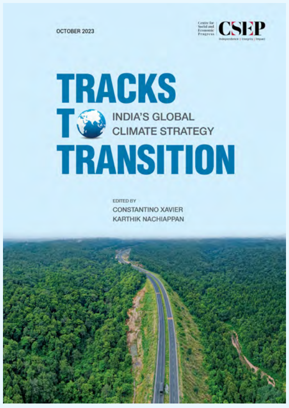
Other publications

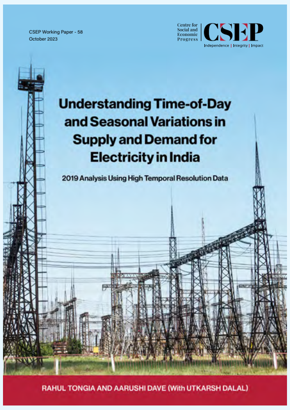


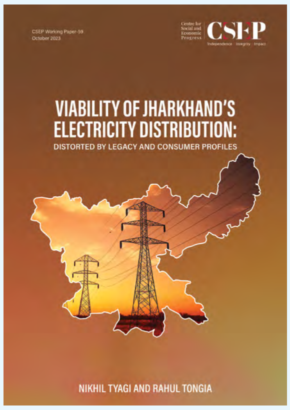


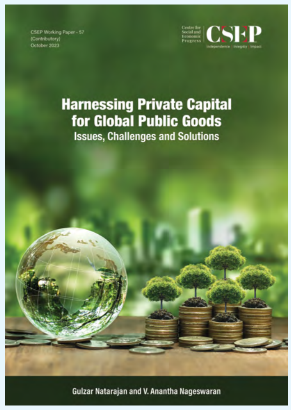


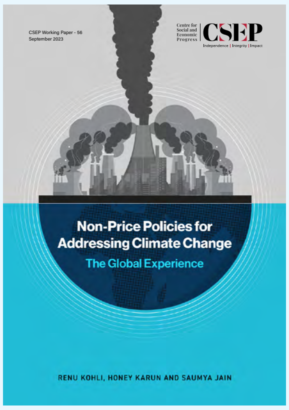


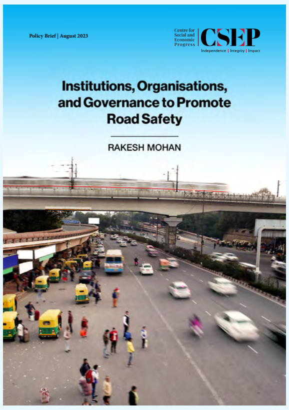


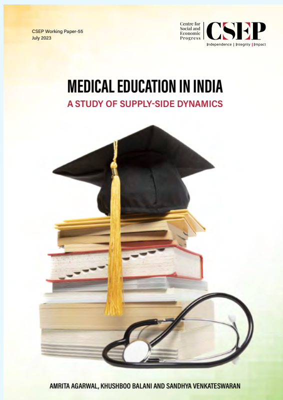


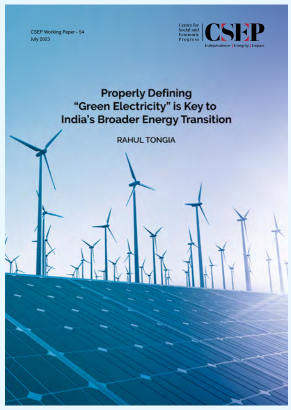


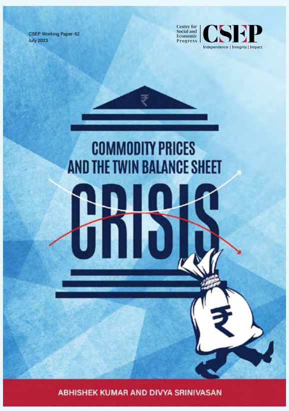


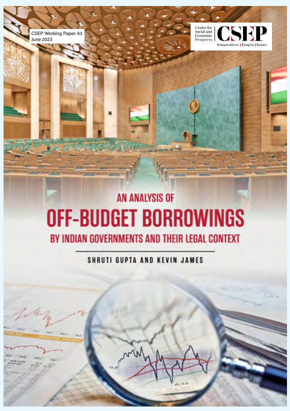












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