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An Integrated Environmental and Fairtrade Labelling Scheme for Product Supply Chains

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Abstract

Environmental initiatives such as carbon labelling have been suggested as a driver for achieving sustainable production systems of product supply chains. The paper therefore presents a systematic process of developing an environmental labelling framework as an extension of carbon labelling using the fairtrade certification as a platform to facilitate the process. Using the general theoretical constructs of lifecycle assessments, the framework presented provides insight into the formulation of multi-regional supply chains which has been specifically characterised in this paper for the UK-India-Rest of the World supply chain. The environmental labelling process presented in this paper is based on two key principles; Quantitative Principle in Eco-labelling and the Principle of Whole Lifecycle Perspective and it is used to inform two key stakeholder groups in the supply chain: consumers and supply chain partners.

For consumers, a consistent way of presenting the environmental label information is presented highlighting the supply chain impacts across the indicators of $CO_{2\text{-eq}}$ emissions, water consumption and land use in addition to regional contributions to these impacts from a global supply chain perspective. Additionally, communicating the environmental impacts to supply chain partners provides a decision support to take actions to reduce the overall impacts by identifying processes within the global supply chain that needed prioritization.

Given that fairtrade partnership is based on participatory development and a strict guidelines and standardization process, it is envisaged that synergies can be derived by integrating environmental labelling with the fairtrade scheme to enhance the environmental sustainability of product supply chains.

Highlights

- A systematic process of developing an environmental labelling is presented
- The framework considers assessment from global product supply chain perspective
- Carbon labelling is expanded upon to also consider water consumption and land use
- The labelling is integrated with fairtrade because of its standardization process

- Labelling informs consumers and provides decision support to supply chain partners

Keywords

Environmental labelling, Carbon emissions; Water Consumption; Land Use; Fairtrade; Sustainability; Global **S**upply chain,; Product lifecycle assessment

1 Introduction

The concept of sustainability has long been an important global challenge but has come to receive prominence and become part of the political rhetoric since the Brundtland Report was published by the World Commission on Environment and Development (1987). Increasingly, sustainability has taken root in business and corporate practices and related supply chains (Genovese et al., 2013) because of increased business accountability expected from stakeholders (Zhu et al., 2008, Barcos et al., 2008). This has therefore forged a strong sense of corporate social responsibility among business entities.

Contemporary issues on Corporate Social Responsibility (CSR) emerged from the broad concept of sustainability but they are rooted in Social Contract Theory (Ramanathan, 1976, Pazner and Schmeidler, 1976) which posits that a sort of implicit social contract exists between business and society and that businesses have some indirect obligations towards society by ensuring that its aggregate impact on society is consistent with social goals and aspirations. It is also an extension of the Theory of Justice which attempts to address the socially just distribution of goods in society; a principle Rawls, (1958) describes as *"Justice as Fairness"*. In recent times, Fairtrade, a scheme which seeks to promote better trading conditions between producers of goods mostly in developing nations and the developed nations (the consumers of these goods) in order to achieve sustainability has been viewed as a practical demonstration of these theories.

Fairtrade is a social movement that operates on the mind-set of facilitating community development by ensuring 'fair' guarantee prices for commodity producers. Generally, fairtrade is seen as a viable alternative means of directing developing countries towards achieving sustainability rather than following the unsustainable western model in order to escape the commodity trap (Strong, 1997).

Fairtrade is operationally defined by ten key principles by the World Fairtrade Organisation (2013) which seemingly cuts across the three pillars of sustainability; that is economic, social and environmental factors. In retrospect, fairtrade has achieve impressive market growth (Carrington et al., 2010, Yamoah, 2014) and many of its objectives as set out in the FINE (an association of the four main fairtrade networks) definition (Bowes, 2011). However, there are pointers in the fairtrade literature showing that sustainable production principle (related to Principle 10: Respect for the Environment) has not been properly aligned to the fairtrade certification process (Elders et al., 2013). For instance, Doherty et al., (2013) suggested that little information exist to show how the sustainable production principle works and there is lack of effective enforcement on the part of the fairtrade authorities.

As a result, the debate on environmental sustainable production has been extended in the fairtrade narrative (De Pelsmacker et al., 2005, Auld et al., 2008) especially given that environmental sustainable production has been widely promoted as a means of minimizing negative impacts on the environment (O'Brien, 1999). Aligned to this, many authors, *inter alia:* (Edwards-Jones et al., 2009, Gadema and Oglethorpe, 2011, Upham et al., 2011) have suggested that environmental initiatives such as carbon labelling can act as a driver for achieving sustainable production systems and consequently reduce emissions in the food supply chains.

Carbon labelling literature however suggests that despite the huge potential the scheme offers, there is no coordinated and formal standardized process in practice (Brenton et al., 2009). Additionally, many studies related to carbon labelling particularly of food products have been undertaken usually targeting consumers at the end of the value chain (Vanclay et al., 2011, Röös and Tjärnemo, 2011). While this can be beneficial in driving consumer consciousness towards sustainability, a creative development of a carbon labelling scheme can be integrated within the fairtrade certification process and communicated throughout the entire supply chain in order to drive initiatives particularly within the production stage in order to promote environmental sustainable production practices. Such an integrated approach of combining environmental labelling within the fairtrade certification process would be beneficial in enhancing environmental sustainability in the supply chain and can be facilitated because of the collaborative nature of stakeholders' engagement which is promoted in fairtrade schemes (Özçağlar-Toulouse et al., 2009, Nelson, 2014).

The paper contributes to the knowledge base by providing theoretical and practical insight into environmental labelling through the fairtrade process by addressing the following research questions:

i. Given the limited and uncoordinated approaches used in carbon-labelling, how can it be extended to environmental-labelling using appropriate framework that streamlines the process and increase the coherence in the assessment process?
ii. How can environmental-labelling be communicated with fairtrade standards and integrated within the decision making process of supply chain management in order to mitigate environmental impacts along the entire value chain?

Hence, using the general theoretical constructs of lifecycle assessments, the paper provides insight into how the methodological framework for environmental ($CO_{2\text{-eq}}$ emissions, water consumption and land use) labelling encompassing the globalized nature of food supply chains is formulated and demonstrated using a case-based approach. The case study uses rice produced in the Khaddar area of Haridwar district in Uttaranchal state, North India as a typical fairtrade food product. A framework for integrating environmental labelling into the fairtrade scheme is also presented.

Carbon emissions, water consumption and land use are chosen as the environmental indicators because while carbon emissions continue to receive global attention because of the link between anthropogenic greenhouse gas emissions and climate change (Sinclaire and Weiss, 2010), for food supply chains, other environmental impacts such as water consumption and land use also become critical (Pfister et al., 2011).

To address the research questions highlighted, the paper is structured as follows: A literature review of the fairtrade certification process and on environmental labelling is presented in Section 2. In Section 3, the methodological process for environmental labelling is formulated and the case study to present the application is presented. The results of the study and the implications within the context of supply chain management are discussed in Section 4. Furthermore, a discussion of the framework for integrating environmental labelling within the fairtrade certification process is provided in Section 4 leading to the concluding remarks in Section 5.

2 Literature Review

2.1 Fairtrade Certification Process

Fairtrade is managed by a network of key stakeholders (FINE), which is made up of Fairtrade Labelling Organizations (FLO International), International Federation for Alternative Trade (IFAT), Network of European World Shops (NEWS), and European Fairtrade Association

(EFTA). FINE summarises the fairtrade concept and its key activities as: 'a trading partnership, based on dialogue, transparency and respect, which seeks greater equity in international trade.

Since its formation in 1997, The Fairtrade Labelling Organisation has played a key role in fairtrade certification. The entire process of fairtrade certification is internationally coordinated by Fairtrade Labelling Organisations International (FLO). The work done by this fairtrade stakeholder leads to the award of a fairtrade mark under the authority of one of its labelling members across various regions of the world. FLO is a non-profit, multi-stakeholder association involving 23 member organisations which develops and reviews fairtrade standards and provides support to fairtrade certified producers by assisting them in gaining and maintaining fairtrade certification and capitalising on market opportunities. The stakeholders forming the FLO are either a labelling agency or producer network.

The actual certification is done by an independent international certification company called FLO-CERT GMBH. This company is responsible for the inspection and certification of producer organisations and traders against the fairtrade standards. There were 746 certified Fairtrade producers worldwide by December 2008. The fairtrade label is a 'Certified™ label' which guarantees that the product(s) carrying the label have been certified against internationally agreed fairtrade standards.

Fairtrade certification has led to a phenomenal market growth of fairtrade products (Bowes, 2011). However, the fairtrade industry's contribution to sustainability has been questioned because the respect for environment principle has not been effectively applied and enforced (Smith, 2010, Bacon, 2010). In a global assessment of the impact of fairtrade, Smith (2010) also observed that fairtrade has not questioned certain agricultural production practices which affect the environment negatively.

These strands of evidence confirm that sustainable production principle (Principle 10: Respect for the Environment) has not been properly aligned to the fairtrade certification process (Doherty et al., 2013). The need for proper alignment of sustainable production within fairtrade certification regime is evident on three fronts:

i. Prevailing environmental problems associated with fairtrade production practices and transportation networks, especially those associated with the continuing certification of plantations (Smith, 2010),

ii. The lack of reliable and objective information on the part of fairtrade authorities to monitor how sustainable production works (Doherty et al., 2013, Bacon, 2010), and
iii. Research evidence indicating fairtrade certification does not necessarily appear to have positive impact on the environment (Elder et al., 2013).

Ruben et al., (2009) for instance argued that the fairtrade premium is not adequate to support environmental improvement activities. Therefore, incorporating carbon labelling into the fairtrade certification process could potentially provide an objective and practical system for factoring environmental sustainability into the fairtrade supply chain.

2.2 Environmental Labelling Accounting

Environmental labelling can generally be described as labelling systems for consumer goods aimed at providing environmental awareness in the global climate change (Solaiman et al., 2011). With regards to food products, carbon labelling as a form of environmental labelling has been adopted as a means of providing consumers with information about the sustainability of food products (Upham et al., 2011, Vanclay et al., 2011). Given that the food industry is the largest manufacturing sector in many developed and developing countries (Li et al., 2014) and because of the potential impacts of food supply chains on the natural environment, carbon labelling as a driver for achieving sustainability of food supply chains should be broadened to environmental labelling consisting of $CO_{2\text{-eq}}$ emissions, water and land use impacts using appropriate frameworks. This is also because for food supply chains, carbon emissions provide an inadequate environmental sustainability measure. Carbon accounting which is a framework for carbon labelling is rooted in ecological foot-printing (Wackernagel and Rees, 2013) and can be defined as the measurement, analysis and reporting of carbon emissions induced ecological impacts of a defined economic system. By extension, environmental labelling accounting can therefore provide a broader system of reporting and communicating the environmental impacts associated with a given product (such as food supply chains) across a range of environmental indicators such as $CO_{2\text{-eq}}$ emissions, water consumption and land use.

A review of extant literature suggests that the concept of food miles which promotes localised sourcing of products as a means of enhancing environmental sustainability has been continuously advocated as a means of measuring sustainability of food products (Weber and Matthews, 2008, Coley et al., 2009). However, a study commissioned by DEFRA (2005), reported that while food transport has significant and growing impacts, a single indicator based on total food kilometres is an inadequate indicator of sustainability. This is because, while transportation associated with moving products within the supply chain contributes to the overall environmental impacts, the entire supply chain must be assessed to identify other areas contributing to high environmental impacts. This characteristic of capturing all impacts (direct and indirect) ensures complete supply chain visibility; a key requirement in environmental impacts measurements across supply chains (Sundarakani et al., 2010).

Generally, environmental assessment frameworks are based on the principle of lifecycle assessment (Sarkis, 2012) which is usually employed to evaluate the environmental profiles of competing products (Collado-Ruiz and Ostad-Ahmad-Ghorabi, 2010) and, by extension, to green certification and labelling (Rajagopalan et al., 2011). Despite the usefulness of lifecycle-based methods which can be used to inform decision making regarding a product's supply chain environmental impacts, there is no current standardised approach employed in applying the methodology in environmental labelling (Brenton et al., 2009); especially so given that the process is voluntary (Weidema et al., 2008). This has led to lack of implementation of such labelling schemes in practice.

Lifecycle based approaches used for calculating product supply chain impacts have generally adopted process-based methodologies (Ibáñez-Forés et al., 2013); the traditional form of LCA methodology (Andersson, 2000). It is however been established that process-based lifecycle approaches inherently suffer from system boundary truncation and as such are not able to deal with the complexity of the global nature of product supply chains (Acquaye et al., 2012, Majeau-Bettez et al., 2011). Despite this, it is able to more accurately evaluate specific environmental implications of inputs into the supply chain system (Sinden, 2009). As such, in order to maintain the advantage offered by process LCA and to overcome the system boundary truncation issues, many studies have suggested the use of hybrid LCA (Minx et al., 2009, Acquaye and Duffy, 2010, Wiedmann et al., 2011, Shrake et al., 2012).

In the hybrid LCA system, process LCA is integrated into complete supply chain system boundary offered by an input-output framework; a top-down macro-economic model of the economy (Wiedmann and Minx, 2007) which captures the whole economic supply chain along with its sectorial changes and production and consumption patterns (Barrett and Scott, 2012). A requirement of green supply chain management is supply chain visibility (Acquaye et al., 2014, Sundarakani et al., 2010); even so for a product supply chain with a globalised network of inputs. The hybrid LCA ensures that this visibility requirement is maintained in any environmental labelling accounting.

In this paper, a Multi-Regional Input-Output (MRIO) hybridized form of the hybrid LCA framework developed using the basic input-output and process LCA concepts are used. It is envisaged that the paper provides insight into how to develop environmental labelling approaches which can be integrated within the fairtrade certification process to ensure that sustainable production is enhanced within product supply chains. In addition, the integrated approach can provide opportunities to identify and pursue continuous environmental improvement of product supply chains.

3. Research Methodology

3.1 Environmental Labelling Framework

The paper adopts the hybrid LCA system approach which integrates process environmental accounting with input-output based environmental accounting into a hybridized framework. The paper however provides further insight into the application of the hybridized framework to environmental labelling by extending the general hybrid model to specifically link the product supply chains of the two countries being studied (UK and India). Because the UK and India are not closed economies to all other countries in the world, the model presented in this paper takes account of the fact that there are also resource flows (products and services) between all other countries from the Rest of the World (ROW) region and the two countries (UK and India) within a consistent framework.

Hence the environmental labelling framework presented in this paper specifically characterises the general hybrid (process and input-output analysis frameworks) lifecycle assessment methodology into a hybridized framework consisting of UK-India-ROW multi-regional input-output framework and process production systems for food systems (rice supply chain used to demonstrate the application in this study).

The following sub-sections outline how the process LCA system, the input-output framework and how these two are combined to form the hybrid framework were derived.

3.1.1 Process LCA System

The process LCA system comprises supply chain inputs that are used directly in the production of the main product ben studies. This is the initial method adopted for computing the environmental impacts of the food production system. Basically, the process-based approach evaluates the amount of supply chain inputs required to produce a given functional unit (in this study 1 kg of fairtrade rice).

The production system shown in Equation 1 is characterised using the process production system defined as $A_p = [k_{rc}]$; where:

A_p Process production system

k Elements of the production system

r (rows) represents inputs (fertilizer, pesticides, etc)

c (columns) processes (such as agricultural production, etc) in the process system matrix

n different types of supply chain inputs

Equation 1:

$$A_p = [k_{rc}] = \begin{cases} k_{rc} = 0 & if\ r \neq c \\ k_{(rc)n} = q_n & if\ r = c \\ k_{rc} = k_{r,n+1} = -k_{rr} & \forall\, r\ and\ if\ c = n+1 \\ k \quad = k \quad = 1 & \end{cases}$$

For n different types of supply chain inputs into the process production system, A_p would be of dimension $(n+1)\ x\ (n+1)$; where there are n supply chain product inputs and 1 main product output q_n represents the quantity of supply chain inputs any of the n inputs. Refer to Appendix I for details of A_p.

The advantage of using process analysis to characterise the initial production system is that because of the specificity of individual inputs accounted for within the defined system boundary, the environmental impacts of those inputs can be more accurately determined (Lenzen and Crawford, 2009). However, because of the system boundary truncation of A_p, it has been described as incomplete, primarily because it may not be possible to account for all the inputs of very complex product supply chains which transcends different countries (Crawford, 2008, Rowley et al., 2009). This limitation is addressed by using the input-output framework.

3.1.2 Input-Output Analysis Framework

The input-output analytical framework is used to calculate upstream indirect impacts associated with the supply chain inputs used in the production of the final product. The principle underlining this is derived from the general input-output model; a quantitative economic technique (Leontief, 1986) which describes the flow of resources (products and services) from one industrial sector considered as a producer to other sectors considered as consumers (Miller and Blair 2009) is used as the methodological basis to account for upstream supply chain environmental impacts in the environmental labelling process.

The process involves transforming the economic flows in the general IO model into physical flows (in this case $CO_{2\text{-eq}}$ emissions, Water and Land) using the basic assumptions of input-output analysis extensively described in literature (Suh, 2009, Acquaye et al., 2011, Kagawa, 2012).

For any economy, the basic IO relationship can be shown to be:

$\underline{x} = A\underline{x} + \underline{y}$ Equation 2

Where:

A mxm matrix of which each column in A describes the domestic and imported intermediate requirements (including raw materials, machinery, energy, goods, transport, services, etc) in monetary values which are required to produce one unit output of the sector.

$\underline{x}$ Total economic output of each industry

$\underline{y}$ Final demand matrix of each industry of which the final consumers are household, government, capital investment and export) denoted by.

Equation 2 reflects linearity assumption of the economy (Miller and Blair, 2009, Lin et al., 2014) in which total production is equal to total consumption; that is, it is assumed that the total output of goods and services produced by industries in an economy ($\underline{x}$) is equal to the total goods and services used by all other industries for their own need ($A\underline{x}$) plus the total goods and services used up by the final demand (eg: government, households, exports) y.

Following on from the linear relationship in Equation 2; the following can be derived in Equation 3:

$\underline{x} = (I - A)^{-1}\Delta\underline{y}$ Equation 3

$(I-A)^{-1}$ is referred to as the Leontief Inverse matrix and $(I-A)^{-1}\Delta\underline{y}$ describes the total (direct and indirect) requirements needed to produce the total output, $\underline{x}$ for a given final demand $\underline{y}$ (Huang et al., 2009). I denotes an identity matrix of dimension mxm. This characteristic of capturing direct and indirect industrial requirements ensures complete supply chain visibility; a key requirement in environmental modelling across supply chains (Sundarakani et al., 2010).

The paper presents an extension to this general approach by characterising the framework to model the overall supply chain of UK-India-ROW and using it as the basis to evaluate upstream environmental impacts used for the environmental labelling process.

Hence, the UK-India-ROW Multi-Regional Input-Output (MRIO) model is characterised and defined as:

$$A_{IO} = \begin{bmatrix} A^{UK,UK} & A^{UK,IND} & A^{UK,ROW} \\ A^{IND,UK} & A^{IND,IND} & A^{IND,ROW} \\ A^{ROW,UK} & A^{ROW,IND} & A^{ROW,ROW} \end{bmatrix} \qquad \text{Equation 4}$$

For example, $A^{IND,UK}$ describes intermediate requirements matrix consisting of supply chain inputs in monetary values from each sector in India (IND) which are required in the UK to produce one unit output by each sector in the UK.

The advantage of the MRIO framework is that it provides an extended system boundary (Acquaye and Duffy, 2010, Mattila et al., 2010, Wiedmann et al., 2011), as such a whole lifecycle perspective is achieved.

3.1.3 Hybridized Framework

The combination of the process LCA system in Section 3.1.1 and the input-output analysis framework offer a hybrid methodology based on an extended system boundary. In this paper, the hybrid model is formulated by integrating the process production system with a multi-regional input-output (MRIO) framework specifically for UK-India-ROW. A detailed explanation of the hybrid LCA methodology is provided in (Acquaye et al., 2011, Wiedmann et al., 2011).

It is an established fact that the hybrid methodology has been well promoted but never applied specifically to environmental labelling of $CO_{2\text{-eq}}$, Water and Land impacts. The paper therefore uses the approach to model the UK-India-ROW supply chain using fairtrade rice as a test case of how the approach can be used to provide insight into how environmental labelling can be integrated into the fairtrade scheme.

To achieve this, A_p (Equation 1) is interconnected with A_{IO} (Equation 4) using the general formula of the integrated hybrid model (Acquaye et al., 2011, Wiedmann et al., 2011) shown in

Equation 5:

$$\text{Total Environmental Impact} = \begin{bmatrix} \hat{E}_p & 0 \\ 0 & \hat{E}_{io} \end{bmatrix} \begin{bmatrix} A_p & -C_d \\ -C_u & (I - A_{io}) \end{bmatrix}^{-1} \begin{bmatrix} y \\ 0 \end{bmatrix} \quad \text{Equation 5}$$

Where:

$\hat{E}_p$ Scaled environmental ($CO_{2\text{-eq}}$, Water and Land) intensities vector of processes in the initial process production system (A_p); $\hat{E}_p$ is presented as a diagonal matrix

$\hat{E}_{io}$ Direct Intensities Matrix for each input-output industry in UK-India-ROW for the environmental indicator ($CO_{2\text{-eq}}$, Water and Land); $\hat{E}_{io}$ is presented as a diagonal matrix

C_u and C_d Upstream and downstream linkages between the input-output system and the process system. Acquaye *et al.*, (2011) provided details of calculating C_u and C_d

y The functional unit in kg denoting the output (1kg) of the initial process system

In addition to the hybrid framework providing a consistent approach to conduct environmental labelling within the fairtrade scheme, a detailed breakdown of the environmental impacts along the UK-India-ROW supply chain can provide useful insight into the supply chain performance thus allowing companies to find significant environmental impacts reduction opportunities.

3.2 Data Sources

Process data was obtained from the Ecoinvent database v2.2 (2010) and used to construct the process system A_p. Because of lack of primary data, the secondary data from ecoinvent was assumed to be representative of production activities. This includes processes for rice production such as soil cultivation, sowing, weed control, fertilisation, pest and pathogen control, irrigation, harvest and the processing of the rice. Machine infrastructure and a shed for machine sheltering are included. Inputs of fertilisers, pesticides and seed as well as their transports to the farm are also considered. The direct emissions on the field are also included. Additionally, Transportation of the fairtrade rice from the production region in India to the UK is assumed to consist of lorry transportation in India (farm to processing plant/warehouse to port), sea transport (India to UK) and lorry transport in the UK. Lifecycle inventory for the transport data was also obtained from Ecoinvent (2010).

The multi-regional input-output tables were collected from the World Input-Output (WIOD) database (WIOD, 2012). The WIOD project is funded by the European Commissions (EC), the 7th Framework programme to construct time-series of world multi-regional input-output tables from 1995 to 2009. The WIOD also provides data on environmental indicators, such as CO_2 emissions, land use, and water consumption, at the industry level which has also been used in this study. As this study is focusing on the UK and India, the 2009 input-output tables from WIOD and their environmental indicators representing the latest year for which a complete data set is available was used. Because the UK and India are not closed economies to the rest of the world countries, the multi-regional input-output framework constructed in this study also considered a third region in addition to UK and India. This third region which was integrated within the MRIO as presented in Section 3.1.2 was the rest of the world (ROW) region.

3.3 Case Study

Fairtrade rice produced in Khaddar area of Haridwar district in Uttaranchal state, North India is chosen as the case study to test the applicability of the environmental labelling framework and ensuing supply chain management challenges. Rice was chosen as the case study because food (with its production challenges in terms of environmental sustainability) has been one of the main product groups within the fairtrade scheme. The Khaddar area in India is famous for the production of huge volume and high quality traditional basmati rice which is fairtrade marked and marketed in Switzerland, France and the UK. According to The Fairtrade Organisation (2005), the average farm size in the area is 1.34 hectares with rice grown on 0.74 hectare with the average production per farmer estimated to be about 1,662kg a year. The lifecycle inventory provided below which was used to construct the process LCA system A_p was obtained from Ecoinvent (2010).

Process Classification	Inputs into Unit Processes	Quantity	Unit
Agricultural Production: Work processes	sowing	0.00016336	hectare
	tillage, cultivating, chiselling	0.00014586	hectare
	tillage, harrowing, by spring tine harrow	0.00072929	hectare
	tillage, ploughing	0.00002917	hectare
	tillage, rolling	0.00014586	hectare
	application of plant protection products, by field sprayer	0.00094808	hectare
	fertilising, by broadcaster	0.00043758	hectare
	combine harvesting	0.00014482	hectare
	grain drying, low temperature	0.1299	kg
	irrigating	1.0783	m3
Agricultural Production: Seed	rice seed	0.020599	kg
Chemicals Application	ammonia, liquid	0.011447	kg
	urea, as N	0.0039593	kg
Mineral Fertilizers Application	ammonium nitrate, as N	0.0054676	kg
	diammonium phosphate, as N	0.0017123	kg
	diammonium phosphate, as P_2O_5	0.0043758	kg
	potassium chloride, as K_2O	0.0037923	kg
Pesticide Application	Specified pesticides	0.000526	kg

Table 1: Lifecycle inventory of rice production system and supply chain (Source: Ecoinvent, 2010)

4. Analysis and Discussion of Results

4.1 Principles of Eco-labelling Process

The paper adopts two key principles in the development of the eco-labelling for product supply chains. These are:

i. Quantitative Principle in Eco-labelling: The environmental labelling process adopted in the paper is based on a quantitative approach developed using the principles of lifecycle assessment in displaying the environmental information of products to the consumer based on the total lifecycle environmental impacts calculated from the hybridized LCA framework. This is because Limnios et al., (2009) reported that quantitative information collected in the assessment of the eco-labels is often not communicated to the consumer and therefore more often than not such labels assumes a qualitative character. This is despite the fact that studies have shown that quantitative display of eco-labels can influence consumer choices (Sammer and Wüstenhagen, 2006, Vanclay et al., 2011).

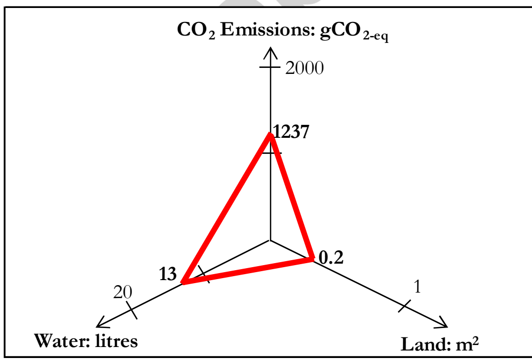
ii. Principle of Whole Supply Chain Perspective: Supply chain collaboration and information sharing has been acknowledged as a process of attaining strategic gains (Holweg et al., 2005) particularly in green supply chain management (Lee et al., 2014).

We adopt this principle for the eco-labelling process used in this paper. It targets consumers based at the end of the supply chain network, the production system based at the beginning of the supply chain network and supply chain partners along the chain.

The analysis and discussion of results therefore follows these principles as outlined in the subsequent sections.

4.2 Communicating Environmental Labelling to the Customer

Total lifecycle environmental ($CO_{2\text{-eq}}$, water and land use) impacts refers to the direct and indirect impacts associated with the production and associated with the product (in this instance 1 kg of fairtrade rice) supply chain. While direct environmental impacts are those impacts directly associated with the production of the rice (such as farm activities), indirect impacts are those that occur for instance in the upstream supply chain (that is activities related to previous production processes such as the manufacture of chemicals and fertilizers used on the farm). Figure 1 is the quantitative presentation of the total lifecycle environmental impacts calculated to be: $CO_{2\text{-eq}}$ emissions (1.237 kg$CO_{2\text{-eq}}$ or 1237 g$CO_{2\text{-eq}}$), water consumption (0.0135m^3 or 13.5 litres) and land use (0.0000218ha or 0.218m^2). This represents the average environmental impact of 1 kg of fairtrade rice consumed in the UK but produced in Khaddar area of Haridwar district in Uttaranchal state, North India.



$CO_{2\text{-eq}}$ [g $CO_{2\text{-eq}}$/kg of rice]	Process System	1139.71
	Upstream: UK	0.57
	Upstream: India	82.74
	Upstream: ROW	14.12
Water [litres/kg of rice]	Process System	0.001
	Upstream: UK	0.008
	Upstream: India	10.82
	Upstream: ROW	2.63
Land Use [m^2/kg of rice]	Process System	0.19
	Upstream: UK	0.00003
	Upstream: India	0.01
	Upstream: ROW	0.01

Figure 1: Environmental ($CO_{2\text{-eq}}$, Water and Land Use impacts) for product supply chain

Figure 1 and its associated data can therefore form the basis of a quantitative representation of an environmental label for the fairtrade rice supply chain. This communicates to the customer the average total environmental impacts across the three indicators and the regional supply chain breakdown that the product causes on the natural environment throughout its lifecycle.

As seen in Figure 1, because the analysis is conducted by characterising the product supply chain into MRIO framework consisting of the UK-India-ROW supply chains, for each of the environmental indicators used in this study, the environmental impacts from the supply chains of the different regions have been captured. The customer is therefore not just informed about the total lifecycle emissions, but on the geographic implications of such impacts.

An analysis of the results indicates that for $CO_{2\text{-eq}}$, and Land Use, the process LCA system were the most important with respective impacts of 92% and 88.5%. For $CO_{2\text{-eq}}$ impacts for instance, of the 92% resulting from the process LCA system, $CO_{2\text{-eq}}$ impacts associated with irrigation contributed 30.6% of the total emissions; the largest of the process LCA system. In the case of water use, upstream water use in India was the most important contributing 80.4% of the total water use.

In this eco-labelling process, the environmental indicators ($CO_{2\text{-eq}}$, Water and Land Use) are considered individually and not combined into a composite indicator or compared to each other to determine the most important environmental issue. This is especially so for food supply chains for which all three indicators are important issues. Also, this approach was chosen because based on the local context, certain environmental indicators may be more relevant.

4.3 Communicating the Implications of Environmental Labelling Process to Supply Chain Partners

Another very important benefit that can be derived from the environmental labelling process relates to how the outcomes from the process is communicated and used to inform the practices of partners within the supply chain. While the actual display of the environmental label should serve as a way of communicating the environmental sustainability agenda to the customer and to serve as a driver to implement change, the environmental labelling process can also provide key partners within the supply chain with information on which parts of the supply chain needs to be targeted to reduce the overall impacts for each indicator.

An analysis of the total lifecycle environmental impacts in terms of carbon emissions for example can be undertaken. In this instance, a detailed analysis can be conducted on the process production system on the farm. See Figure 2 below:

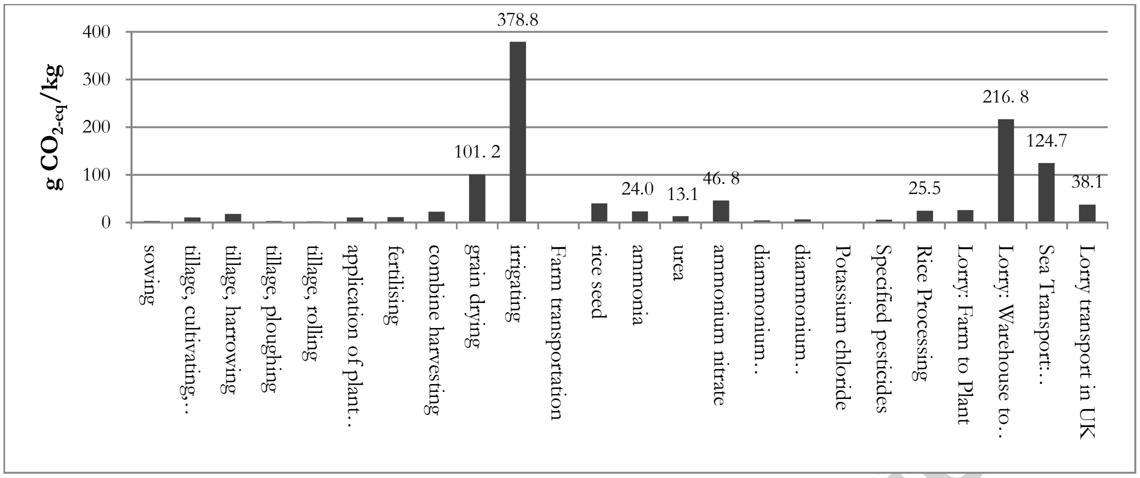


Figure 2: Breakdown of CO_{2-eq} emissions in the process LCA system

As a way of informing and providing evidence to implement decarbonisation strategies in order to enhance sustainable production (Principle 10 of the Fairtrade scheme), it is evident that certain activities of the production system must be targeted because of their contributions to the total lifecycle emissions. These top five processes within the rice supply chain include irrigation (378.8 gCO_{2-eq}; 30.6%), Lorry Transport: Warehouse/Processing Plant to India Port (216.8 gCO_{2-eq}; 17.5%), Sea Transport-India to UK (125 gCO_{2-eq}; 10%); Grain Drying (101.2 gCO_{2-eq}; 8.2%) and Ammonium Nitrate Fertilizer (46.8 gCO_{2-eq}; 3.8%). Evidently, operationally oriented supply chain strategies for instance can be used to address the impacts involving transport activities and grain drying. The results also confirms that the environmental impacts of food supply chains should not be conducted on a food miles perspective given that in terms of food mile, transportation contributed 32.8% of the total emissions which would leave other important processes in the supply chain unaddressed.

In recent times, issues related to water scarcity particularly in regions at risk of water drought has brought the issue of embodied water to the forefront of supply chain management (Blackhurst et al., 2010, Feng et al., 2011). Given that some of the water consumed is not directly linked to the operations of the focal firm but is embodied within the supply chain, it raises key questions about how these can be accounted and managed.

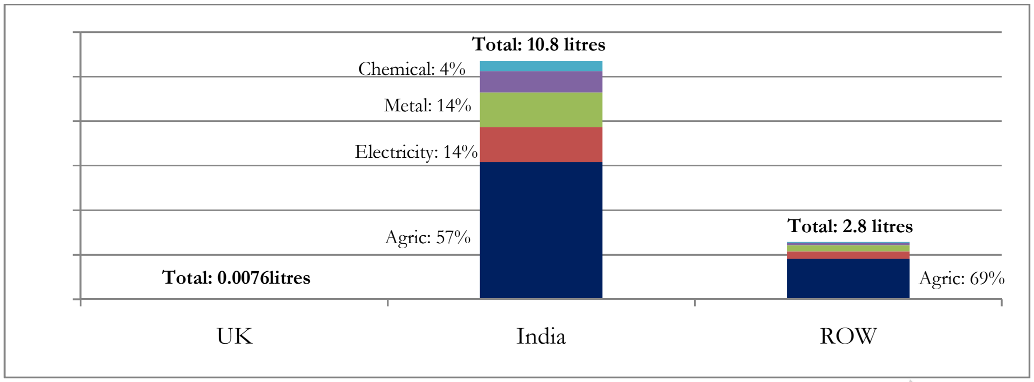


Figure 3: Indirect water by sectors in different geographic regions embodied in the product supply chain

Figure 3 provides a breakdown of the top 5 water embodied in the operations of upstream supply chain categorized by industrial sector which contributes to the total water use associated with the product supply chain in each geographic location.

Given the interconnected nature of global supply chains, land used to produce goods and services are both direct and indirect. In the case of the fairtrade rice produced in India but consumed in the UK for example, this UK demand and other supply chain inputs triggers local land use changes in different geographic locations (such as in India and other ROW countries) because of the globalised nature of the supply chains. Feng et al (2013) referred to this phenomenon as tele-connection of local consumption to global land use.

By using the MRIO framework in this study, embodied land in the rice upstream supply chain as a result of consumption in the UK can be evaluated. Figure 4 below illustrates the implications of embodied land in the supply chain. Despite the UK triggering the demand for rice, it can be observed that the large proportion of land used in the upstream supply chain does not occur in the UK which is 3.2×10^{-5} m^2. Significantly larger land use in India (0.011m^2) and the ROW region (0.0141m^2) are rather displaced.

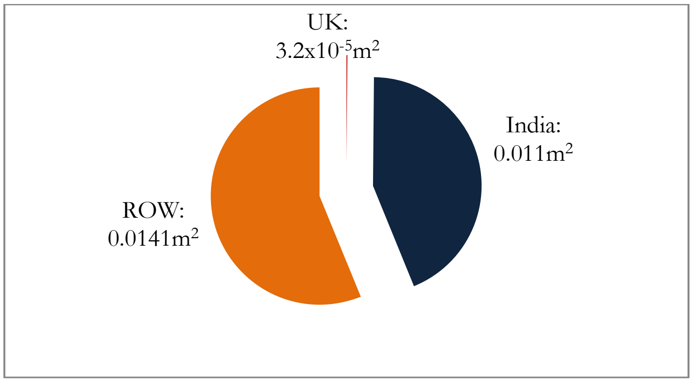


Figure 4: Upstream land use by geographic region

4.4 Supply chain management and implications of an integrated environmental labelling and fair trade certification framework

Presented below is an integrated framework that links the environmental labelling approach with the fairtrade certification process. The two processes can be operationally linked from two perspectives. Firstly, the environmental labelling framework can be integrated with the fairtrade certification process at the stage where regional-based FLO-CERT is undertaken (indicated as (1) in Figure 5). At this stage of the certification process, data from product supply chain, partners and in the production process can be collated and used within the hybridized framework to generate the environmental labels. This particular integration would place the emphasis on the customer specifically on how to better communicate the environmental impacts based on $CO_{2\text{-eq}}$, water and land use impacts indicators.

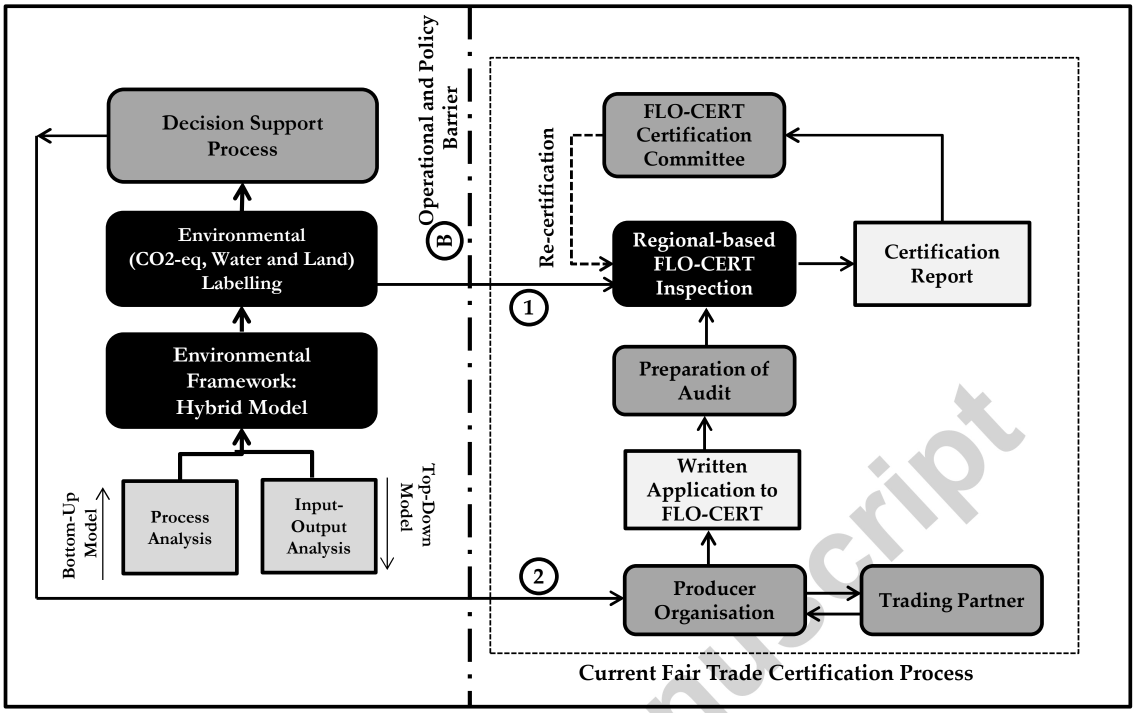


Figure 5: Integrated Environmental Labelling and Fair Trade Certification Framework

The environmental labelling framework and the fairtrade certification process can also be operationally linked to the fairtrade certification scheme at the producer organisation level (indicated as (2) in Figure 5). At this stage, the emphasis of the integration between the two frameworks is the producer organisation and its supply chain partners. The output of the environmental labelling framework can also form the basis to provide decision support and a knowledge base to the producer organisation in terms of identifying aspects within the food supply chain where high environmental impacts exist; either domestically/imported or from inputs used in the production system. Information from these will provide operational opportunities to implement appropriate low carbon strategies to reduce the overall impacts of the food supply chain.

As indicated in the integrated framework, there are some barriers (indicated by the boundary (B) in Figure 5) that needs to be overcome before such a scheme can be effectively implemented. These barriers include data issues, supply chain management challenges, and standardization challenges.

Data access and data quality for lifecycle assessment purposes has been a limiting factor in the effective use of the process within decision support process. As highlighted by Tillman (2000), decisions regarding choice of data such as the use of site-specific data or data representing an average can affect reliability of results when modelling a system. Heijungs (1996) and Wiedmann (2008) both suggested that issues related to reliability of data can therefore be addressed by having a rough estimate of the margins of uncertainty. In addition to this, operational measures can also be used to address data issues. When environmental labelling is integrated into the fairtrade scheme, data management can be better managed through standardization process within the integrated framework because the fairtrade process already follows strict guidelines and standardization process (Renard, 2005).

Methodologically, the general input-output methodology by its nature suffers from inherent limitations such as homogeneity and proportionality assumptions (Acquaye and Duffy, 2010). The homogeneity assumption for instance proposes that each sector produces a uniform output using identical inputs and processes. However, this is not the case since each sector may be a representation of many different products or services, and even for the same product, different technologies may be used in its production. Wiedmann et al., (2011) and Li et al., (2012) proposes different disaggregation techniques to address these issues. Ideally, the ROW region referred to in this study should be broken down into individual countries to specifically account for explicit country impacts. While the underlying methodology remains the same, because of data limitations and scope of the study, the disaggregation of the ROW region into individual countries has not been possible.

Supply chain management challenges related to such integration can involve problems of effective collaboration between supply chain partners. A key supply chain management philosophy is striving to achieve optimized efficiency and productivity and this requires a strong commitment to close relationships among partners. It is generally believed that increased collaboration among supply chain partners leads to enhanced service performance (Cao and Zhang, 2011). Through supply chain collaborations and partnerships, knowledge sharing and communication of information from the environmental labelling process can help turn strategic intent into an organisational reality (Wagner et al., 2002) by helping reduce the environmental impacts along the supply chain.

The benefit of integrating environmental labelling with the fairtrade certification process is also because of the synergy that can be derived from a much closer collaboration which is promoted in the fairtrade supply chain by taking advantage of the ethical dimension of the fairtrade partnership which is based on participatory development and closer collaboration in supply chain networks. Indeed, Tallontire (2000) reiterates that fairtrade has evolved from solidarity to a partnership model, emphasising the importance of participation by the producer partner. Hence, as shown from the results (See Figures 2, 3 and 4 for instance), supply chain information such as environmental impacts (either in production system, domestic/imported supply chains) can be identified and through better collaborations and partnerships, these can be communicated and effective intervention measures implemented to reduce the impacts.

4.5 Validation of Model and Eco-Labelling Process

The results generated follow the principles of LCA which is underpinned by the ISO 14044 Principles and Framework for Lifecycle Assessment (International Standard Organisation, 1998). The framework sets out the standard to be used to address the environmental aspects and potential environmental impacts throughout a product's life cycle. Despite this, the LCA standards do not prescribe any specific assessment methodology; for instance for eco-labelling purposes (Brenton et al., 2009). However, over the years, scientific literature (*inter alia:* (Suh and Nakamura, 2007, Rowley et al., 2009, Acquaye et al., 2011, Lee and Ma, 2013) and international published reports (*inter alia:* (IPCC, 2007, UNESCO, 2012) has recognised the role that methodologies for LCA purposes such as hybrid approaches (as used in this paper) play in environmental assessments and analysis.

From a supply chain management perspective, it is envisaged that as a result of the very strict guidelines and standardization process of the fairtrade system, integrating environmental labelling with the fairtrade scheme can enhance the validation process throughout the supply chain.

Data issue is another important subject in the validation process of environmental assessments (Tillman, 2000). Internationally recognized and validated data sources such as Ecoinvent (2010) can be used in the case of secondary data needs. For primary data sources, the role of the fairtrade standardization process as put forward in this paper becomes even more important.

5. Conclusions

The paper presents a systematic process of developing an environmental labelling framework using the fairtrade certification scheme as a platform to facilitate the process. It argues that the fairtrade certification scheme has been beneficial process in enabling community development by ensuring local farmers and partners involved in the supply chain are guaranteed 'fair' prices for the commodity they produce. While this particularly ensures social and economic development, in terms of environmental sustainability evidence from literature suggest that sustainable production principle (related to Principle 10 of the fairtrade process) has not been properly aligned to the fairtrade certification process. Using the concept of carbon labelling but extending it to a much broader context of environmental labelling ($CO_{2\text{-eq}}$ emissions, water consumption and land use), the paper therefore provides insight into how environmental labelling process can be integrated with the fairtrade certification process to enhance environmental sustainable supply chains

Given the uncoordinated approaches used in carbon-labelling and by extension, environmental labelling, the paper provides insight into the formulation of multi-regional supply chains specifically characterised for the UK-India-Rest of the World through a framework emanating from the general theoretical constructs of lifecycle assessments. The methodology enables both direct and indirect supply chain impacts to be captured hence achieving complete visibility of the supply chain; a key principle in green supply chain management.

Based on the underlying methodology and using a case-based approach to demonstrate its application, an environmental labelling analysis was presented for fairtrade rice produced in the Khaddar area of Haridwar district in Uttaranchal state, North India and consumed in the UK. The paper argues that environmental labelling as a means of communicating environmental sustainability in the supply chain must be targeted at two stakeholder groups: to consumers and to supply chain partners involved in the production process.

For consumers, a consistent way of presenting the quantitative information is presented highlighting the supply chain impacts across the indicators of $CO_{2\text{-eq}}$ emissions, water consumption and land use in addition to regional contributions to these impacts from a global supply chain perspective. Additionally, communicating the environmental impacts to supply chain partners provides the means to take actions to reduce the overall impacts. As such the study provided information and insight into decision support in terms of environmental impacts on the product supply chain such as a detailed breakdown of $CO_{2\text{-eq}}$ emissions of the production system, water consumption from the of upstream supply chain based on the regional contribution of key processes and indirect land use. Furthermore, the study reinforced the notion that using food files as a measure of environmental sustainability is an inadequate measure of environmental sustainability of food products given that food mile contributed only 32.8% of the total lifecycle emissions in the case study adopted.

The paper finally presents an integrated framework that can operationally link the environmental labelling approach with the fairtrade certification process to inform consumers and also provide decision support to production partners; although there are some barriers such as data access and quality and supply chain management issues that need to be overcome before such a scheme can be effectively implemented. Because the fairtrade partnership is based on participatory development, a much stronger supply chain network and involves strict guidelines and standardization process, it is envisaged that synergies can be derived by integrating environmental labelling with the fairtrade scheme to enhance the environmental sustainability of the entire supply chain.

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Appendix I: Process LCA system for the production of 1 kg of Rice

	sowing	tillage, cultivating, chiselling	tillage, harrowing, by spring tine harrow	tillage, ploughing	tillage, rolling	application of plant protection products, by field sprayer	fertilising, by broadcaster	combine harvesting	grain drying, low temperature	irrigating	Farm transportation	rice seed, at regional storehouse	ammonia, liquid, at regional storehouse	urea, as N, at regional storehouse	ammonium nitrate, as N, at regional storehouse	diammonium phosphate, as N, at regional storehouse	diammonium phosphate, as P_2O_5, at regional storehouse	potassium chloride, as K_2O, at regional storehouse	Specified pesticides	Rice Processing	Lorry: Farm to Processing Plant and Processing Plant to Regional Warehouse	Lorry: Regional Warehouse to India Port	Sea transport: India port to UK port	Local Lorry transport in UK	Output: Rice
sowing	**0.0001634**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.00016336
tillage, cultivating, chiselling	0	**0.0001459**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.00014586
tillage, harrowing, by spring tine harrow	0	0	**0.0007293**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.00072929
tillage, ploughing	0	0	0	**2.917E-05**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.00002917
tillage, rolling	0	0	0	0	**0.0001459**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.00014586
application of plant protection products, by field sprayer	0	0	0	0	0	**0.0009481**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.00094808
fertilising, by broadcaster	0	0	0	0	0	0	**0.0004376**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.00043758
combine harvesting	0	0	0	0	0	0	0	**0.0001448**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.00014482
grain drying, low temperature	0	0	0	0	0	0	0	0	**0.1299**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.1299
irrigating	0	0	0	0	0	0	0	0	0	**1.0783**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1.0783
Farm transportation	0	0	0	0	0	0	0	0	0	0	**0.0047987**	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.0047987
rice seed, at regional storehouse	0	0	0	0	0	0	0	0	0	0	0	**0.020599**	0	0	0	0	0	0	0	0	0	0	0	0	-0.020599
ammonia, liquid, at regional storehouse	0	0	0	0	0	0	0	0	0	0	0	0	**0.011447**	0	0	0	0	0	0	0	0	0	0	0	-0.011447
urea, as N, at regional storehouse	0	0	0	0	0	0	0	0	0	0	0	0	0	**0.0039593**	0	0	0	0	0	0	0	0	0	0	-0.0039593
ammonium nitrate, as N, at regional storehouse	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0.0054676**	0	0	0	0	0	0	0	0	0	-0.0054676
diammonium phosphate, as N, at regional storehouse	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0.0017123**	0	0	0	0	0	0	0	0	-0.0017123
iammonium phosphate, as P_2O_5, at regional storehouse	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0.0043758**	0	0	0	0	0	0	0	-0.0043758
potassium chloride, as K_2O, at regional storehouse	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0.0037923**	0	0	0	0	0	0	-0.0037923
Specified pesticides	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0.000562**	0	0	0	0	0	-0.000562
Rice Processing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**1**	0	0	0	0	-1
essing Plant and Processing Plant to Regional Warehouse	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0.2**	0	0	0	-0.2
Lorry: Regional Warehouse to India Port	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**1.622**	0	0	-1.622
Sea transport: India port to UK port	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**11.6**	0	-11.6
Local Lorry transport in UK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0.285**	-0.285
Output: Rice	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1