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JUTE ECOLABEL

Life Cycle Assessment of Jute Products

www.jute.com/ecolabel
THE GOLDEN NATURAL FIBRE

May 2006

Background

The National Jute Policy 2005 aims at augmenting jute and jute products exports by 2010 through a multi-pronged strategy. National Jute policy emphasizes a new commodity development strategy to focus on positioning jute as a superior and eco-friendly material, enhancing the productivity of raw jute, increasing exports through innovative marketing and improving the working conditions of the workers. According to the WTO Committee on Trade and Environment, well-designed eco-labelling programs can be effective instruments of environmental policy. In order to improve the marketability of Indian Jute products overseas, highlighting the environment-friendly attributes of jute, JMDC conceived the introduction of an ecolabel for Indian jute products. The aim of the Ecolabel was to create visibility in the export market as well as to provide information to consumers and enable them to select products that are less harmful to the environment.

Jute Manufactures Development Council (JMDC), Ministry of Textiles, Government of India retained PricewaterhouseCoopers Pvt. Ltd. to conduct the study on 'Life Cycle Analysis Study of Jute to develop a Ecolabelling protocol" in order to be able to harness the emerging green markets in developed economies such as the European Union and the USA. These countries have a growing green customer base for sustainable and eco-friendly products. Life cycle considerations in an ecolabel encourage providing the end-use customers with information regarding disposal of the products after their useful life. Ecolabelling in jute is intended to stimulate environmental design across the life cycle from cradle to grave in keeping with emerging buyer requirements. Therefore the purpose of the life cycle assessment study was to identify the impacts across the life cycle from cradle to grave with respect to conventional and non-conventional practices that would have a direct bearing on the ecolabel and disposal protocol development.

How to read this document

This document has been developed as a background document to the Jute ecolabel document. Keeping in mind the intended application of the present life cycle assessment study, this document has been divided into different sections supported by technical details as appendices. The objective of this document is to give a detailed scenario of impacts based on which the ecolabel has been developed. The appendices include such documentation that would be of interest to readers who wish to learn how the LCA study led to the development of Ecolabel criteria. A glossary of useful terms is included for ready reference.

Glossary of frequently used terms

Environmental aspect: element of an organization's activities, products or services that can interact with the environment

Functional unit: quantified performance of a product system for use as a reference unit in a life cycle assessment study

Input: material or energy which enters a unit process

Life cycle assessment, LCA: compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle

Life cycle impact assessment: phase of life cycle assessment aimed at understanding and evaluating the magnitude and significance of the potential environmental impacts of a product system

Life cycle interpretation: phase of life cycle assessment in which the findings of either the inventory analysis or the impact assessment, or both, are combined consistent with the defined goal and scope in order to reach conclusions and recommendations.

Life cycle inventory analysis: phase of life cycle assessment involving the compilation and quantification of inputs and outputs, for a given product system throughout its life cycle

Output: material or energy which leaves a unit process

Waste: any output from the product system which is disposed of

Product system: collection of materially and energetically connected unit processes which performs one or more defined functions

Raw material: primary or secondary material , that is used to produce a product

System boundary: interface between a product system and the environment or other product systems

Elementary flow:

(1) material or energy entering the system being studied, which has been drawn from the environment without previous human transformation

(2) material or energy leaving the system being studied, which is discarded into the environment without subsequent human transformation

Unit process: smallest portion of a product system for which data are collected when performing a life cycle assessment

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Chapter
1

Objective

The objectives of the study were :

- to estimate emissions and resources use at unit process levels for all the stages of life cycle, viz. handling and transportation, process use, recycle, reuse and disposal
- to undertake a life cycle inventory of emissions and resource use in jute manufacturing units as well as upstream and downstream processes;
- to undertake assessment of Life Cycle Impacts for the current practices and alternate improvement pathways (Process technology, fuels and raw materials)

The main purpose of the study was to formulate the ecolabel protocol and disposal protocol for selected Indian Jute products. The purpose of this study is to develop an ecolabel protocol based on Conceptual Life Cycle Assessment study in line with relevant ISO 14040 guidelines applicable to the Jute Industry in India.

The present LCA study systematically addresses the environmental aspects of product systems, from raw material acquisition to final disposal. The intended application of the study is not to make any comparative assertion or to formulate any product declaration. The International Environmental Labelling Standard ISO 14024 lays down the requirements for the preparation of an ecolabel protocol (Type I) based on Life Cycle considerations and hence has been used in this study. Consequently, this study has draws upon relevant LCA guidelines of ISO 14040 as applicable for the preparation of an ecolabel protocol for jute as required by the ISO 14024 standards.

Chapter
2

Structure of the Report

The Life cycle assessment report was developed based on the basic requirements of the International standard ISO 14040. Accordingly, the report is divided into the following sections:

- Goal and scope of the study
- Life cycle Inventory analysis
- Life cycle Impact assessment
- Life cycle Interpretation
- Life cycle Improvement analysis and
- Conclusions

Chapter
3

Goal and Scope of the study

The Life cycle assessment of jute products has been carried out on a cradle to grave basis[1]. "Cradle" denotes the agricultural phase of jute while "grave" denotes the final disposal of the products after their use and its assimilation in the environment. Further, with stakeholders input, the overall scope of the study was decided and accounted for through the first quarterly report in May, 2005. The scope of this conceptual LCA was defined as follows:

Delineation of system boundary:

The system boundary for the LCA leading to type I ecolabel included production of jute fiber, processing of jute fiber for manufacturing different jute products and use and disposal of jute products as depicted in Fig 1.

The entire life cycle of jute can be categorized in three phases:

- **Phase I: Cradle to Gate Phase,** i.e. growing of raw jute; a cradle to gate approach, comprising of the following sub-phases:
  - Cultivation and production of fibre
  - Transportation from farm to mill

The raw jute fibre production, i.e. Phase I, has India as the geographical boundary for this study, as the jute used is only sourced from India. Therefore environmental impacts in the Indian scenario are considered during agricultural and retting phase.

- **Phase II: Gate to Gate Phase,** i.e. processing of fibre into finished products by mills.

This includes processing raw jute within the mill premises, delineation of impacts of additional processing for select jute products (i.e. dyeing, bleaching etc.). This phase is divided into unit processes such as selection, batching, spinning, drawing, twisting, weaving, bleaching dyeing etc. to capture the data for different product categories at different unit process levels. This phase also accounts for the environmental impacts resulting from the transportation of finished jute products from mill gate to the export markets. The manufacturing units selected are all located in India. Temporally, this study uses the most recent data available for processes either with the jute mills or from relevant literature.

[1] The scope was discussed with JMDC during the inception meeting held on 15th February 2005.

- **Phase III: Gate to Grave Phase or Use and disposal of the product;** a gate to grave approach, comprising the following sub-phases
  - Transportation to end-user
  - Use and reuse, recycle or disposal of jute products by the ultimate consumers

On the disposal side, the recycle/disposal options such as recycle of the used product for the manufacturing of non-woven textile material and disposal options such as land filling in managed landfills, incineration and waste to energy, composting etc. have been considered.

Defining function of the product system and functional unit:

The ecolabel study covers product categories as decided in the inception meeting i.e. Jute Yarn, Jute Hessian, Food grade jute bags, Shopping bags, Floor covering and Jute geotextiles. The product category scopes have been largely selected based on export potential of items that have select BIS specification. For cases where there are no specific standards available for products, such as in the case for Floor covering and shopping bag, the product function characteristics have been decided based on the specific product that has maximum export potential. The functional units have been identified for select six jute products keeping in view life cycle impacts. The functional unit has been drawn from standardized specification of exported items as shown in the following table.

Sr. No.	Product category	Functional Unit
1	Yarn (carpet Quality)	16 lb , 2 ply yarn as per IS 13188:2002 performing as the input to carpet weaving process
2	Hessian	Hessian cloth of 9 X 10 size , 40" length and 8 oz weight (as per IS 2818 I-VI standard)
3	Food grade jute Hessian or bag (FGJH and FGJB respectively	Hydrocarbon free B twill, 6 x 8, 44" x 26.5", 1020 gm carrying 90 kg weight (IS 2566: 93 version), used for 1 times
4	Jute Geotextiles (JGT)	Type II: 500gm/sq.meter; 6.5 x 4.5 threads/dm; 122cm (Woven jute IS 14986: 2001 version) is used to cover the unit soil surface and 1050 gm/sq. meter (specification for non-woven variety) is used to cover the unit soil surface.
5	Floor covering (FC)	15 X 12; 1237 gm/sq meter used to cover the unit surface over a period of 4 years
6	Shopping bag	Size of 16.5"/13.5"/6" with cane handle (7 inch radius) weighs 240 gm (No BIS/Standard specification is available) uses for the shopping purpose

The scope of the product categories as defined has been compared with function of competing synthetic products that provide equivalent use2.

Preparation of life cycle inventory

The initial tasks included the preparation of life cycle inventory of emissions and resource use in cultivation of jute, transportation of jute from farm to mill, processing of jute into finished products, use and disposal of jute products. These are based on authenticated secondary data collected directly from the mills or from literature sources.

Review of life cycle inventory data

The collected information and data were reviewed through jute experts and also submitted to JMDC for review.

Modeling Of Jute Life Cycle Processes

Modeling of Jute Life Cycle Processes in TEAM (Tools for Environmental Analysis and Management) software.

Impact Assessment

Assessment of impact on various environmental indicators e.g. non-renewable resource depletion, non-renewable energy resources depletion, global warming, air acidification, eutrophication, ozone depletion, human and aquatic toxicity etc. Impact identification and assessment was based solely as per the TEAM software.

Interpretation of Impacts based on their magnitude, importance on local / global level and identification of problem areas (if any) which need improvement.

Delineation of alternative improvement pathways with respect to process technology, fuels and raw materials.

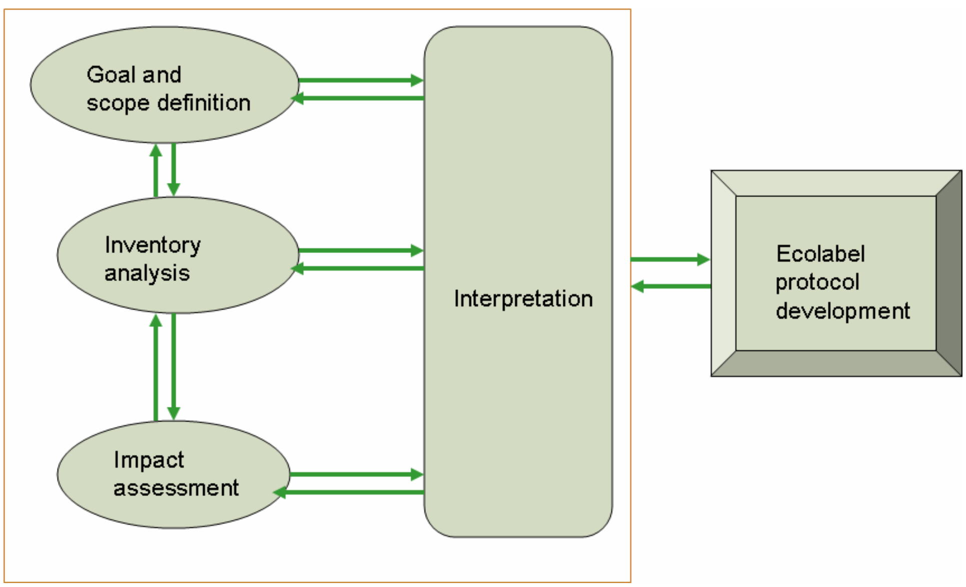
[2] During the stakeholder consultation in London, several stakeholder expressed the view that aesthetics of the product may also be considered.

Chapter
4

Life Cycle Inventory

General description of life cycle inventory:

The definition of the goal and scope of a study provided the initial plan and direction for conducting the LCA study. The life cycle inventory analysis (LCI) was concerned with the data collection and calculation procedures. The operational steps outlined in the following figure were performed.



The life cycle inventory (LCI) is an account of all mass and energy inputs and outputs to the life cycle systems. The inputs and outputs are expressed for each functional unit, e.g. for Floor covering, inputs and outputs for a certain area of floor covering. In the inventory analysis, data was collected and input and outputs were attributed to the individual processes. The inventory table is generated based on the aggregation of all inputs and output data collected throughout the life cycle stages. The life cycle inventory presents a detailed outline of process tree (the product system), system boundaries, data gathering, allocation of data and product wise resulting inventory table.

For undertaking the present LCA study, the software, Tools for Environmental Management and Analysis (TEAMTM 4.0), was procured from Ecobilan, France. TEAM™ 4.0 is software with high flexibility, modularity and high potential of evolution, with a user-friendly interface. It is currently considered to be one of the best software for LCA based simulations and analyses. The data collected as a part of LCI was checked for its suitability for use with the TEAM software.

TEAM Software, Tool for LCA study:

TEAM Package consists of an integrated suite of software tools such as : modeling tools used for describing physical operations. It allows the user to build a large database and to calculate Life Cycle Inventories for complex systems (inventories conducted for a product's life cycle or other consistent systems), in full adherence to the methodological guidelines developed for this technique. The main principles underlying the design of this tool are flexibility, modularity and high potential of evolution, user-friendly interface analysis tools for applying assessment methods (impacts, valuations, etc) on the inventories resulting from the model that describes the system under study.

Data has been utilized from two databases that were available with TEAM package:

- DEAM Starter Kit (DEAM stands for Data for Environmental Analysis and Management) that includes data sets (modules) that cover most common industry sectors or activities encountered while performing Life-Cycle Inventory Analysis.
- DEAM Methods that includes the state of the art impact assessment and valuation methods.

Data Collection and Calculation procedure:

As mentioned in the scope of the study, this study used secondary data wherever such reliable literature or other unit level data management source became available. In cases where reliable secondary data were not available, primary data have been captured (for example, analysis of jute product samples, HBO etc.). The secondary data sources were various international, national and government published public domain data and mill data sources. Data collection and calculation procedure for three phases was as follows:

- **Phase I or Cradle to Gate Phase:** For agricultural phase secondary data from national and international sources for Indian jute have been used. As suggested by JMDC, PwC professionals visited Dacca and procured the IJSG publication on Environmental Assessment of Jute Agriculture, 2000 that was used as a reference. Likewise, national data on agricultural raw material and production that has been published by Government of India have been used in the study. PricewaterhouseCoopers retained SGS Pvt. Ltd. to analyze the environmental parameters for some of raw jute samples. The total agricultural process was divided into two unit processes like agricultural process and retting process. All data have been collected as input and output to the unit processes. The collected data was calculated according to the input or output to each unit process and expressed as input or output per unit of raw jute produced. As the intended application of the present study is to identify impacts during life cycle phases of Indian jute products, the agricultural data was restricted to the national boundary.

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- **Phase II or Gate to Gate Phase:** For gate to gate, i.e. the manufacturing phase, the data has been collected from different Jute mills as well as dyeing, bleaching unit, lamination unit and shopping bag manufacturing units. As delineated in the scope of the study, the data collection in this phase was restricted to production of selected six jute products such as jute yarn, Hessian, Food grade quality Hessian or Jute bag, Floor covering, Jute Geotextiles and shopping bag. As discussed in the inception meeting held on 15th February 2005, JMDC had provided a list of leading manufacturers of jute products. Through research and consultation process we identified other jute products manufacturer from whom LCI data could be collected. The jute manufacturers and experts were consulted and a database of Jute products manufacturing processes in terms of raw material usage, chemical usage, wastes and energy requirement was prepared. We divided the jute product manufacturing process into a number of unit processes. A questionnaire on both the preliminary and detailed data collection was formulated and circulated among the selected jute manufacturers covering products under the scope of the study in order to collect mill based actual input and output data on a unit process wise basis. The questionnaire is annexed as Annex1. The list of mills from which data have been collected is annexed as Annexure 2. On the basis of the data collected and discussion with Jute experts and technologists, final process balance sheet including both material and energy input-output has been developed and used as inventory data sheets. For transportation by light weight truck (16 tonne) and Heavy weight truck (28 tonne), the DEAM database data was used. For transboundary export of jute products by sea, a fixed distance in nautical mile has been considered for the present study. Intergovernmental Panel on Climate Change values on the emission were used for the ship transportation.

  The samples of raw materials, additive chemicals, finished products and water and wastewater were collected and analyzed by SGS Ltd. on behalf of PwC using internationally accepted sampling procedures and testing methods. Gaseous emissions and energy related data were taken from monitoring and testing reports submitted by the mills to the Pollution Control Board. The data has been collected for the most recent financial year.

  The various input and data either supplied by the mills or collected from various departments of the mill, were entered in a block diagram and an approximate mass balance prepared to detect any inconsistency. A few values in the mass balance have been checked and corrected in consultation with the mill technical personnel. The verification of data has been done with a joint effort of Jute mill personnel and experts.

- **Phase III OR Gate to Grave Phase**: For this phase, the primary as well as secondary data has been collected. We have developed inventory depending on inputs from analysis result submitted by SGS, secondary published literature like PCC Technical guidance, IPCC guideline etc. and DEAM data base inputs. Data has been analysed for two different disposal systems : incineration and landfill system.

Data requirement as to LCA:

Data quality requirements specify in general terms the characteristics of the data needed for the study. Data quality requirements were defined to enable the goals and scope of the LCA study to be met. Data quality requirements are summarized as follows:

Data Aspect	Phase I: Agricultural data	Phase II: Manufacturing data	Phase III: Disposal data
Time related coverage	√	√	√
Geographical coverage	√	√	√
Technology coverage	Not applicable	√	√
Precision (Varience)	√	√	√
Completeness	Not applicable	√	√
Representativeness	√	√	√
Consistency and reproducibility	√	√	

As per ISO 14040, the data required for an LCA study may be collected from the production sites associated with the unit processes within the system boundaries, or they may be obtained or calculated from published sources. In practice, all data categories may include a mixture of measured, calculated or estimated data. Data categories should be considered when deciding which data categories are used in the study. The following table indicates how the data categories have been addressed in the present LCA study:

Data category	Treatment in this LCA study
Energy inputs and outputs	treated as any other input or output to an LCA. The various types of energy inputs and outputs included inputs and outputs relevant to the production and delivery of fuels, feedstock energy and process energy used within the system being modeled.
Emissions to air, water and land	Discharges from point or diffuse sources, after passing through emissions control devices, fugitive emissions. Indicator parameters, e.g. biochemical oxygen demand (BOD)
Resource consumption	Total water consumption has been taken into account

Data requirement as to TEAM:

The data are collected and calculated as per requirement of TEAM 4.0 version software which were used to calculate and collate the impacts during the product life cycle phase. The data are calculated using TEAM software. As defined in the TEAM software, assessment methods calculations are performed from an assessment methods database included in the software, encompassing the relevant impacts. In this database, "effects" are defined, which list "contributors" and their "weight". Performing data analysis with help of TEAM software basically covers the following analysis

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Data analysis	Performed by TEAM
Link analysis	Yes
Correlation analysis	Yes
Statistical analysis	Yes
Simulation analysis	Yes, (sensitivity analysis)

Qualitative and Quantitative description of unit processes:

The life cycle of six different jute products - yarn, Hessian, Food grade Jute sacking bag, Jute geotextile (both woven and non-woven or felt), Jute floor covering and shopping bag have been considered in the present study. To describe and capture the impacts of life cycle for each product, a number of unit processes were introduced into a system. The qualitative and quantitative descriptions of unit processes are annexed in Annex 3.

Modeling of Jute Life Cycle Processes in TEAM:

This section details the modeling that was performed for the detailed process stages, and presents how methodological decisions were applied during the LCA study.

Process Stage Grouping: With help of the participating mills, and experts from jute industries, flow charts leading to the production of selected jute products were prepared by PwC. These flow charts generated discussion on how the processes could be grouped into black boxes (Unit processes) are depicted in Annex 4.

All the unit processes listed in Annexure 4 were modeled in TEAMTM 4.0 within their respective subsystems. The subsystems were then connected to each other in order to obtain a system. The system was then checked for consistency and subsequently normalized against the functional unit of respective jute products.

This consistent and normalized system was taken up for impact system and used for the life cycle assessment study for analyzing the impacts.

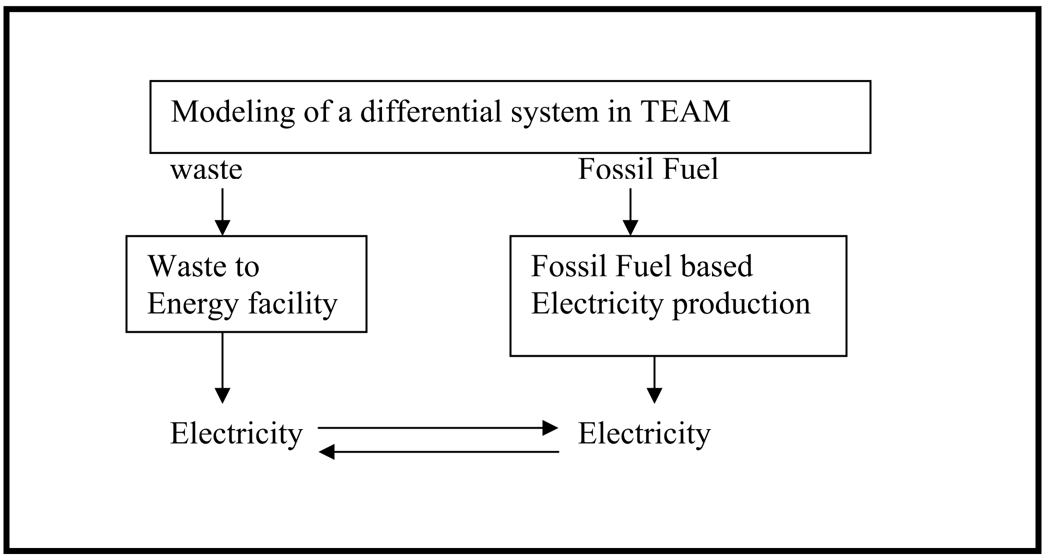
Allocation principles and procedure:

In line with the ISO 14040 standard, the allocation principles and procedures are well defined in the data requirement of TEAM. It was thought proper to avoid allocation by decided that allocation for this study would be avoided to the maximum extent possible. Instead, the unit processes were divided into sub-processes and all the applicable inputs and outputs were collected for these sub-processes.

During disposal of jute products by landfilling, the scenario of capturing methane for energy production has been considered. The credit has been given to the jute life cycle for following incineration method of disposal and hence contributing to waste to energy method of energy production. The avoided impacts have been considered for waste to energy method of energy production as compared to the conventional type of energy production.

Avoided impacts are derived from an allocation method in which all burdens of the process are allocated to the co-product of interest. Burdens of alternative production processes producing the co-products that are not of interest are subtracted from the burdens of the system under study, translating the fact that the co-production of these co-products might avoid their production through more classical production processes.

As shown in the following figure, the classical electricity production process will be subtracted from the total system, as a result of the avoided impact connected with the electricity by-production of the Waste to Energy Facility, when jute is incinerated or landfilled with methane capture at the disposal phase.



Life Cycle Inventory for product system:

Collected and collated data have resulted in a database with processes and accompanying inputs and outputs, also known as, flows. These processes data are collated based on the functional unit of respective product system. The test results of the environmental parameters have been also used as a supporting document to formulate the inventory. An inventory table is then the result of aggregation and scaling all data for the process tree.

In this LCA study, calculations were made using TEAM software. The inventory tables of the respective product system are annexed as Annexure 5.

Assumptions:

To perform the inventory data analysis throughout the development of life cycle inventories, the following assumptions were made:

Life Cycle Phase	Parameter	Assumption
Agricultural Phase	Emissions to soil due to pesticide (pyrethoid cypermethrion) activity	It is assumed that the entire chemical ends up as run-off water as an extreme case. But the half life of the product is 4.8 day. So there is almost no chance of the residual remaining on the jute fibre. Hence this is a conservative approach.
Manufacturing Phase	CO2 emission due to Purchased electricity	It is calculated on the basis of assumption that the electricity is sourced from a grid with 80% thermal component
Manufacturing Phase	Energy consumed	assuming that the power contribution from DG set during power failure as negligible
Manufacturing Phase	Allocation	To avoid allocation in different unit processes that produce both jute fibre and jute waste (caddies), the system boundary was extended to include the recycled waste as well as steam generation process
Disposal Phase	Methane generated from landfill	Jute contains 41% carbon. According to IPCC guideline on biogas and methane generation from biomass, 50% of total carbon content is biogas and 50% of biogas is methane.
Disposal Phase	Methane captured	80% of methane is being captured as is a typical case in EU and USA

Limitations:

The life cycle assessment study addresses only the environmental issues that are identified in the goal and scope. Therefore, the scope of the present study is limited to the intended application of the present study. The following limitations have been addressed in the present LCA study.

Stages of LCA	Limitation
Goal/Scope/Functional Unit	Aesthetic property of jute has not been considered
Goal/Scope	Capital equipment and Human capital were out of the scope of the present study
Life Cycle Impact Assessment	Absence of spatial and temporal resolution – The normalization of emissions from the system unit operations to one functional unit erases all temporal and geographical characteristics, which are needed to assess

	local environmental impacts (was the emission instantaneous and localized or spread over a large geographical area over a long period of time?).
Life Cycle Impact Assessment	**Absence of threshold information – LCA is based on a linear extrapolation of mass loadings with the assumption that this loading contributes to an environmental effect. This non-threshold assumption contradicts several environmental and toxicological mechanisms. While this characteristic proves to be a reasonable assumption for impact categories such as global climate change, it counters the impact assessment categories dealing with toxicity (human and ecological toxicity).**

Chapter
5

Life Cycle Impact Assessment:

Life Cycle Impact Assessment (LCIA), requirement as to LCA:

As defined in the ISO 14040, the Life Cycle Impact Assessment is the phase of life cycle assessment aimed at understanding and evaluating the magnitude and significance of the potential environmental impacts of a product system. The Life Cycle Impact Assessment phase models selected environmental issues, called impact categories, and uses category indicators to condense and explain the LCI results. These category indicators are intended to reflect the aggregate emissions or resource use for each category, and represent the potential environmental impacts of the product system. TEAM version 4.0 software has been used to assess the life cycle impacts. In the present study, the requirement for assignment and calculation of LCI results to the impact categories addressed by TEAM is as follows:

Parameter	Comments
Classification and Characterization	**As stated in ISO 14042[3], classification provides guidance for assignment of LCI results to impact categories. The calculation involves the conversion of LCI results to common units and the aggregation of the converted results within the impact category. This conversion uses characterization factors. The outcome of the calculation is a numerical indicator result.**
Normalization	**All the unit processes were modeled in TEAM™ 4.0 within their respective subsystems. The subsystems were then connected to each other in order to obtain a system. The system was then checked for consistency and subsequently normalized against the functional unit. This consistent, normalized system was then taken up for impact assessment, improvement analysis and interpretation.**
Grouping	**This procedure assigns impact categories into one or more sets and involves sorting (e.g., by characteristics such as global, regional and local spatial scales) and/or ranking (e.g., high, medium or low priority).**
Weighting	**Weighting is the process of converting and aggregating indicator results, possibly across impact categories (e.g., adding acidification impact to global warming impact).This process has been addressed by Ecopoint indicator 95 method of assessment.**

[3] ISO 14042: International standards for Environmental management — Life cycle assessment — Life cycle impact assessment

Selection of Impact Categories:

As defined in ISO 14040 "the impact assessment phase of an LCA is aimed at evaluating the significance of potential environmental impacts using the results of the life cycle inventory analysis". The Life Cycle Impact Assessment phase models selected environmental issues, called impact categories, and uses category indicators to condense and explain the LCI results. These category indicators are intended to reflect the aggregate emissions or resource use for each category, and represent the potential environmental impacts of the product system.

It should be noted that the category indicators should be related to category endpoints, which are attributes or aspects of natural environment, human health, or resources, identifying an environmental issue of concern.

There are different impact assessment methods like Ecoindicator 95 (Goedkoop, 1995), ExternE method (EC, 1995), EPS system (Steen, 1993; Steen 1996). The method used in this study is referred to as the CML 2000 method and IPCC Greenhouse gas method.

The CML 2 baseline method elaborates the problem-oriented (midpoint) approach. It includes both characterization and normalization.

The general framework of LCIA is composed of several mandatory elements that convert LCI results to category indicator results: Selection of impact categories, category indicators, and models. This element entails identification of the impact categories, related indicators, indicator models, category endpoints and associated LCI results that the LCA study has addressed.

The assessment methods of TEAMTM 4.0 included 31 impact and 13 valuation types that could be classified into three groups of widely recognized environmental problems viz.:

- Depletion (of biotic and abiotic resources)
- Pollution (greenhouse effect, depletion of ozone layer , acidification, etc)
- Damage (to ecosystems and human health)

In line with the selection requirement the following impact categories have been selected:

Impact category	Definition in respective method(i.e. CML or IPCC)	Applicability to the present study/ Comments
CML- Air acidification	**The inventory data assigned to the CML-Air Acidification characterization method are the 10 acidifying compounds which are potentially transformed into acid compounds through reactions with atmospheric elements.** **Although Ammonia is a base, Ammonia emission to the air is included as it may be potentially oxidized and releases H+.**	**the source of Eutrophication is presence of phosphate, expressed in terms of g eq. PO4.**
CML- Aquatic Ecotoxicity	**Freshwater aquatic ecotoxicity, freshwater sediment ecotoxicity, marine ecotoxicity factor for characterizing**	**eq. Zn water is the impacted Aquatic**

	Aquatic ecotoxicity	Eco-toxicity resulted from Phenol in retting process
CML-Eutrophication	The Eutrophication index is similar to the one used for CML. It deals with terrestrial and aquatic nutrification. The 13 articles included are all the nutritive compounds containing either phosphorus or nitrogen which are released in the environment either in air (elementary articles which are indicated by the "a)"sign in the inventory) or in water (elementary articles which are indicated by the "w)"sign in the inventory). As oxygen depletion is an intermediary step towards the final consequences of eutrophication (ecosystem shift and depletion), the elements oxidized chemically or biologically when released into the environment are also considered when examining eutrophication. This explains why the CML eutrophication index includes Chemical Oxygen Demand (COD).	the source of Eutrophication is presence of phosphate in water, emission of Nitrogenous gases etc.
CML-Eutrophication (water)	The Eutrophication (water) index is an amended version of an index produced by CML. It has been introduced by Ecobilan as the CML oxygen depletion index does not seem to be an adequate index for terrestrial nutrification. The Eutrophication (water) index is restricted to water eutrophication. The flows included are the emissions of nutritive compounds in water and COD.	Presence of COD and Phosphate in the water is the main source of Water eutrophication.
CML- Human toxicity	This factors for characterizing human toxic releases, for infinite and 100 year time horizons and global scale	The PO4 and Fluoride are the main contributor to Human Toxicity.
CML- Terrestrial ecotoxicity	This factors for characterizing presence of toxic substances in land,soil etc.	the source of Eutrophication is presence of phosphate
IPCC-Greenhouse effect (direct, 20, 100 and 500 years)	This indicator follows IPCC guideline. The indicator results is expressed in kg of the reference substance, CO2, GWP is the Global warming potential of substances integrated over a years. The potential direct effects on global warming ('the Greenhouse Effect') of the emission of 38 'greenhouse' gases is considered.	Global warming due to indirect CO2 equivalent emission due to utilizing electricity from grid was predicted 20 years, 100 years and 500 years respectively assuming the same rate of CO2 emission using IPCC'S methodology.

Out of the total available 13 valuation indicator, the following indicator has been selected for the present study:

Valuation Indicator	Comments
Environmental Priority Strategy (EPS)	**EPS method (Environmental Priority Strategies) is a valuation system: emissions and extractions are valued to a common measure so that they can be added. Emissions are thus multiplied by an environmental load index to yield a dimensionless Environmental Load Unit (ELU).** **EPS method is applied to selected articles belonging to the main types of flows between the environment and the studied system:air, water, land use, metal resources and non renewable energy**
Ecopoints	**Ecopoints are calculated by multiplying the flows obtained in the inventory by ecofactors, when such a factor exists, by adding those pertaining to a group (for a total of four groups: air emissions, water emissions, energy and waste) and by totaling each subscore to create a general score. Ecopoints method is applied to selected articles belonging to the main types of flows between the environment and the studied system: air, water and waste and energy**
Critical Volumes	**Critical volumes are an attempt to encompass toxicological aspects of a system. Critical volumes method is applied to selected articles belonging to the main types of flows between the environment and the studied system: air, water**
Eco-indicator 95	**in the Eco-indicator method, the weighing factor (We) applied to an environmental impact index (greenhouse effect, ozone depletion, etc.) stems from the "main" damage caused by this environmental impact.** **This main damage may be one of the following: five percent ecosystem impairment, one extra death per million inhabitants per year, health complaints as a result of smog episodes.**

Environmental Impact Assessment of Jute products:

The inventorised data for selected jute products like jute yarn, Hessian, Food grade quality jute Hessian or sacking, Jute geotextiles, Floor covering and shopping bag have been analyzed through TEAM software on the basis of above selected impact categories and indicators to identify and quantify the environmental impacts throughout different phases of lifecycle. The consolidated results for respective jute products are as follows:

Product Category:	Yarn
Product Name:	Jute yarn
Product Specification:	16 lb X 2 ply as per standard IS 13188: 2002

PHASE I

The following results indicate the cultivation and retting phase of Jute life cycle. This result is applicable for the raw jute cultivated in 1 hectare of land and the final raw jute (dried fibre) which has been produced after retting process of that 1 ha. output, that is, 3 tonne of jute.

Sr. No	Impact	Specification	Value	Unit
1	IPCC-Greenhouse effect (direct 100 years)	CO2, CO2 equivalent CH4	-4502370	g. eq. CO2
2	CML-Eutrophication	Phosphate (PO4 3-, HPO4-, H3PO4, AS P) (W)	NA	g eq. PO4
3	CML-Air-acidification	Sulphur dioxide and Nitrogen Oxides (Sox as SO2 and Nox as NO2)	NA	g.eq.H+

PHASE II

The following results indicate the manufacturing phase of Jute life cycle. This result is applicable for the 684 tonne of jute yarn.

	For Phase II			
Sr. No	**Impact**	**Specification**	**Value**	**Unit**
1	IPCC-Greenhouse effect (direct 100 years)	CO2, CO2 equivalent CH4	485.71	g. eq. CO2
2	CML-Eutrophication	Phosphate (PO4 3-, HPO4-, H3PO4, AS P) (W)	NA	g eq. PO4
3	CML-Air-acidification	Sulphur dioxide and Nitrogen Oxides (Sox as SO2 and Nox as NO2)	NA	g.eq.H+

PHASE III

Disposal through Incineration

The following results indicate the disposal of the jute yarn or its product (in case of carpet, we have considered only the jute part in terms of total jute quantity, that is one tonne of jute). Here we also have considered the credits against the energy production, which actually contributed to the replacement of fossil fuel utilisation.

	Incineration			
Sr. No	Impact	Specification	Value	Unit
1	IPCC-Greenhouse effect (direct 100 years)	CO2, CO2 equivalent CH4	-6.895	g. eq. CO2
2	CML-Eutrophication	Phosphate (PO4 3-, HPO4-, H3PO4, AS P) (W)	NA	G eq. PO4
3	CML-Air-acidification	Sulphur dioxide and Nitrogen Oxides (Sox as SO2 and Nox as NO2)	NA	g.eq.H+

Landfill

The following results indicate the disposal of the jute yarn or its product (in case of carpet, we have considered only the jute part in terms of total jute quantity, that is one tonne of jute). Here we also have considered that 50% of the methane emission will be captured and only 50% will be emitted.

Sr. No	Impact	Specification	Value	Unit
1	IPCC-Greenhouse effect (direct 100 years)	CO2, CO2 equivalent CH4	14.127	g. eq. CO2
2	CML-Eutrophication	Phosphate (PO4 3-, HPO4-, H3PO4, AS P) (W)	NA	g eq. PO4
3	CML-Air-acidification	Sulphur dioxide and Nitrogen Oxides (Sox as SO2 and Nox as NO2)	0.0001104	g.eq.H+

Product Category:	Packaging material
Product Name:	Jute Hessian
Product Specification:	9 X 10 size, 40" length and 8 oz weight (as per IS 2818 I-VI standard)

PHASE I

The following results indicate the cultivation and retting phase of Jute life cycle. This result is applicable for the raw jute cultivated in 1 hectare of land and the final raw jute (dried fibre) which has been produced after retting process of that 1 ha. output, that is, 3 tonne of jute.

Sr. No	Impact	Specification	Value	Unit
1	IPCC-Greenhouse effect (direct 100 years)	CO2, CO2 equivalent CH4	-4502370	g. eq. CO2
2	CML-Eutrophication	Phosphate (PO4 3-, HPO4-, H3PO4, AS P) (W)	NA	g eq. PO4
3	CML-Air-acidification	Sulphur dioxide and Nitrogen Oxides (Sox as SO2 and Nox as NO2)	NA	g.eq.H+

PHASE II

The following results indicate the manufacturing phase of Jute life cycle. This result is applicable for the 677.4 tonne of jute Hessian.

For Phase II				
Sr. No	**Impact**	**Specification**	**Value**	**Unit**
1	IPCC-Greenhouse effect (direct 100 years)	CO2, CO2 equivalent CH4	531.00	g. eq. CO2
2	CML-Eutrophication	Phosphate (PO4 3-, HPO4-, H3PO4, AS P) (W)	NA	G eq. PO4
3	CML-Air-acidification	Sulphur dioxide and Nitrogen Oxides (Sox as SO2 and Nox as NO2)	NA	g.eq.H+

PHASE III

Disposal through Incineration:

The following results indicate the disposal of the jute Hessian. Here we also have considered the credits against the energy production, which actually contributed to the replacement of fossil fuel utilisation.

	Incineration			
Sr. No	Impact	Specification	Value	Unit
1	IPCC-Greenhouse effect (direct 100 years)	CO2, CO2 equivalent CH4	-7.612	g. eq. CO2
2	CML-Eutrophication	Phosphate (PO4 3-, HPO4-, H3PO4, AS P) (W)	NA	G eq. PO4
3	CML-Air-acidification	Sulphur dioxide and Nitrogen Oxides (Sox as SO2 and Nox as NO2)	NA	g.eq.H+

Landfill

The following results indicate the impacts for disposal of the jute Hessian. We have considered that 50% of the methane emission will be captured and only 50% will be emitted.

Sr. No	Impact	Specification	Value	Unit
1	IPCC-Greenhouse effect (direct 100 years)	CO2, CO2 equivalent CH4	15.1257	g. eq. CO2
2	CML-Eutrophication	Phosphate (PO4 3-, HPO4-, H3PO4, AS P) (W)	NA	g eq. PO4
3	CML-Air-acidification	Sulphur dioxide and Nitrogen Oxides (Sox as SO2 and Nox as NO2)	0.0001401	g.eq.H+

Product Category:	Geotextiles
Product Name:	Jute Geotextiles and Jute Felt (Non-woven Jute Geotextiles)
Product Specification:	Type II: 500gm/sq.meter; 6.5 x 4.5 threads/dm; 122cm (Woven jute IS 14986: 2001 version) is used to cover the unit soil surface and 1050 gm/sq. meter (specification for non-woven variety) is used to cover the unit soil surface.

PHASE I:

The following results indicate the cultivation and retting phase of Jute life cycle. This result is applicable for the raw jute cultivated in 1 hectare of land and the final raw jute (dried fibre) which has been produced after retting process of that 1 ha. output, that is, 3 tonne of jute.

Sr. No	Impact	Specification	Value	Unit
1	IPCC-Greenhouse effect (direct 100 years)	CO2, CO2 equivalent CH4	-4502370	g. eq. CO2
2	CML-Eutrophication	Phosphate (PO4 3-, HPO4-, H3PO4, AS P) (W)	NA	g eq. PO4
3	CML-Air-acidification	Sulphur dioxide and Nitrogen Oxides (Sox as SO2 and Nox as NO2)	NA	g.eq.H+

PHASE II:

For Jute Geotextile (woven type)

The following results indicate the manufacturing phase of Jute geotextile (woven type) life cycle. This result is applicable for the 242.36 tonne of jute geotextiles leading to production of 483 nos. of finished bales.

For Phase II				
Sr. No	**Impact**	**Specification**	**Value**	**Unit**
1	IPCC-Greenhouse effect (direct 100 years)	CO2, CO2 equivalent CH4	120.72	g. eq. CO2
2	CML-Eutrophication	Phosphate (PO4 3-, HPO4-, H3PO4, AS P) (W)	NA	G eq. PO4
3	CML-Air-acidification	Sulphur dioxide and Nitrogen Oxides (Sox as SO2 and Nox as NO2)	NA	g.eq.H+

For Jute Geotextile (Non-woven type)

The following results indicate the manufacturing phase of Jute geotextile (non-woven type) life cycle. This result is applicable for the 1000 tonne of jute geotextiles leading to production of 483 nos. of finished bales.

	For Phase II			
Sr. No	**Impact**	**Specification**	**Value**	**Unit**
1	**IPCC-Greenhouse effect (direct 100 years)**	**CO2, CO2 equivalent CH4**	**612.14**	**g. eq. CO2**
2	**CML-Eutrophication**	**Phosphate (PO4 3-, HPO4-, H3PO4, AS P) (W)**	**NA**	**G eq. PO4**
3	**CML-Air-acidification**	**Sulphur dioxide and Nitrogen Oxides (Sox as SO2 and Nox as NO2)**	**NA**	**g.eq.H+**

PHASE III

Since the intended applications of the jute geotextiles was using it as soil saver. Therefore the following results indicates the final phase of Jute geotextile life cycle. Here, we have considered that 50% of the methane emission will be captured and only 50% will be emitted.

Sr. No	Impact	Specification	Value	Unit
1	**IPCC-Greenhouse effect (direct 100 years)**	**CO2, CO2 equivalent CH4**	**14.823**	**g. eq. CO2**
2	**CML-Eutrophication**	**Phosphate (PO4 3-, HPO4-, H3PO4, AS P) (W)**	**NA**	**g eq. PO4**
3	**CML-Air-acidification**	**Sulphur dioxide and Nitrogen Oxides (Sox as SO2 and Nox as NO2)**	**0.00013**	**g.eq.H+**

Product Category:	Floor covering
Product Name:	Jute Floor covering
Product Specification:	15 X 12; 1237 gm/sq meter used to cover the unit surface area

PHASE I

The following results indicate the cultivation and retting phase of Jute life cycle. This result is applicable for the raw jute cultivated in 1 hectare of land and the final raw jute (dried fibre) which has been produced after retting process of that 1 ha. output, that is, 3 tonne of jute.

Sr. No	Impact	Specification	Value	Unit
1	IPCC-Greenhouse effect (direct 100 years)	CO2, CO2 equivalent CH4	-4502370	g eq. CO2
2	CML-Eutrophication	Phosphate (PO4 3-, HPO4-, H3PO4, AS P) (W)	NA	g eq. PO4
3	CML-Air-acidification	Sulphur dioxide and Nitrogen Oxides (Sox as SO2 and Nox as NO2)	NA	g eq. H+

PHASE II

The following results indicate the manufacturing phase of Jute Floor covering life cycle. This result is applicable for the 34.97 tonne of jute Floor covering .

For Phase II				
Sr. No	**Impact**	**Specification**	**Value**	**Unit**
1	IPCC-Greenhouse effect (direct 100 years)	CO2, CO2 equivalent CH4	579.61	g. eq. CO2
2	CML-Eutrophication	Phosphate (PO4 3-, HPO4-, H3PO4, AS P) (W)	NA	G eq. PO4
3	CML-Air-acidification	Sulphur dioxide and Nitrogen Oxides (Sox as SO2 and Nox as NO2)	NA	g.eq.H+

PHASE III

Disposal through Incineration:

The following results indicate the disposal of the Jute Floor covering. Here we also have considered the credits against the energy production, which actually contributed to the replacement of fossil fuel utilisation.

	Incineration			
Sr. No	**Impact**	**Specification**	**Value**	**Unit**
1	**IPCC-Greenhouse effect (direct 100 years)**	**CO2, CO2 equivalent CH4**	**-7.751**	**g. eq. CO2**
2	**CML-Eutrophication**	**Phosphate (PO4 3-, HPO4-, H3PO4, AS P) (W)**	**NA**	**g.eq.PO4**
3	**CML-Air-acidification**	**Sulphur dioxide and Nitrogen Oxides (Sox as SO2 and Nox as NO2)**	**NA**	**g eq. H+**

Landfill

The following results indicate the disposal of the Jute Floor covering. We have considered that 50% of the methane emission will be captured and only 50% will be emitted.

Sr. No	Impact	Specification	Value	Unit
1	**IPCC-Greenhouse effect (direct 100 years)**	**CO2, CO2 equivalent CH4**	**15.127**	**g. eq. CO2**
2	**CML-Eutrophication**	**Phosphate (PO4 3-, HPO4-, H3PO4, AS P) (W)**	**NA**	**g.eq.PO4**
3	**CML-Air-acidification**	**Sulphur dioxide and Nitrogen Oxides (Sox as SO2 and Nox as NO2)**	**0.00013**	**g eq. H+**

Product Category:	Food grade packaging
Product Name:	Hydrocarbon Free Jute Bag
Product Specification:	Hydrocarbon free B twill, 6 x 8, 44" x 26.5", 1020 gm carrying 90 kg weight (IS 2566: 93 version)

PHASE I

The following results indicate the cultivation and retting phase of Jute life cycle. This result is applicable for the raw jute cultivated in 1 hectare of land and the final raw jute (dried fibre) which has been produced after retting process of that 1 ha. output, that is, 3 tonne of jute.

Sr. No	Impact	Specification	Value	Unit
1	IPCC-Greenhouse effect (direct 100 years)	CO2, CO2 equivalent CH4	-4502370	g. eq. CO2
2	CML-Eutrophication	Phosphate (PO4 3-, HPO4-, H3PO4, AS P) (W)	NA	g.eq.PO4
3	CML-Air-acidification	Sulphur dioxide and Nitrogen Oxides (Sox as SO2 and Nox as NO2)	NA	g eq. H+

PHASE II

The following results indicate the manufacturing phase of Hydrocarbon free food grade bag life cycle.

For Phase II				
Sr. No	**Impact**	**Specification**	**Value**	**Unit**
1	IPCC-Greenhouse effect (direct 100 years)	CO2, CO2 equivalent CH4	446.00	g. eq. CO2
2	CML-Eutrophication	Phosphate (PO4 3-, HPO4-, H3PO4, AS P) (W)	NA	g.eq.PO4
3	CML-Air-acidification	Sulphur dioxide and Nitrogen Oxides (Sox as SO2 and Nox as NO2)	NA	g eq. H+

PHASE III

Disposal through Incineration:

The following results indicate the disposal of the Food grade Jute bag. Here we also have considered the credits against the energy production, which actually contributed to the replacement of fossil fuel utilisation.

	Incineration			
Sr. No	Impact	Specification	Value	Unit
1	IPCC-Greenhouse effect (direct 100 years)	CO2, CO2 equivalent CH4	-7.127	g. eq. CO2
2	CML-Eutrophication	Phosphate (PO4 3-, HPO4-, H3PO4, AS P) (W)	NA	g.eq.PO4
3	CML-Air-acidification	Sulphur dioxide and Nitrogen Oxides (Sox as SO2 and Nox as NO2)	NA	g eq. H+

Landfill

The following results indicate the disposal of the Food grade Jute bag in a landfill.

Sr. No	Impact	Specification	Value	Unit
1	IPCC-Greenhouse effect (direct 100 years)	CO2, CO2 equivalent CH4	15.034	g. eq. CO2
2	CML-Eutrophication	Phosphate (PO4 3-, HPO4-, H3PO4, AS P) (W)	NA	g.eq.PO4
3	CML-Air-acidification	Sulphur dioxide and Nitrogen Oxides (Sox as SO2 and Nox as NO2)	0.00011	g eq. H+

Product Category:	Shopping Bag
Product Name:	Jute Shopping bag
Product Specification:	16.5x6x13.5 with Cane handle weighs 240 gm. There is no standard for shopping bag

PHASE I

The following results indicate the cultivation and retting phase of Jute life cycle. This result is applicable for the raw jute cultivated in 1 hectare of land and the final raw jute (dried fibre) which has been produced after retting process of that 1 ha. output, that is, 3 tonne of jute.

Sr. No	Impact	Specification	Value	Unit
1	IPCC-Greenhouse effect (direct 100 years)	CO2, CO2 equivalent CH4	-4502370	g. eq. CO2
2	CML-Eutrophication	Phosphate (PO4 3-, HPO4-, H3PO4, AS P) (W)	NA	g.eq.PO4
3	CML-Air-acidification	Sulphur dioxide and Nitrogen Oxides (Sox as SO2 and Nox as NO2)	NA	g eq. H+

PHASE II

The following results indicate the manufacturing phase of Shopping bag life cycle.

For Phase II				
Sr. No	**Impact**	**Specification**	**Value**	**Unit**
1	IPCC-Greenhouse effect (direct 100 years)	CO2, CO2 equivalent CH4	624.71	g. eq. CO2
2	CML-Eutrophication	Phosphate (PO4 3-, HPO4-, H3PO4, AS P) (W)	NA	g.eq.PO4
3	CML-Air-acidification	Sulphur dioxide and Nitrogen Oxides (Sox	NA	g eq. H+

		as SO_2 and Nox as NO_2)		

PHASE III

For Disposal through Incineration:

The following results indicate the disposal of the Shopping bag. Here we also have considered the credits against the energy production, which actually contributed to the replacement of fossil fuel utilisation.

	Incineration			
Sr. No	Impact	Specification	Value	Unit
1	IPCC-Greenhouse effect (direct 100 years)	CO_2, CO_2 equivalent CH_4	-7.905	g. eq. CO_2
2	CML-Eutrophication	Phosphate (PO_4 3-, HPO_4-, H_3PO_4, AS P) (W)	NA	g.eq.PO_4
3	CML-Air-acidification	Sulphur dioxide and Nitrogen Oxides (Sox as SO_2 and Nox as NO_2)	NA	g eq. H^+

LANDFILL

The following results indicate the disposal of the Jute Floor covering. We have considered that 50% of the methane emission will be captured and only 50% will be emitted.

Sr. No	Impact	Specification	Value	Unit
1	IPCC-Greenhouse effect (direct 100 years)	CO_2, CO_2 equivalent CH_4	15.4285679	g. eq. CO_2
2	CML-Eutrophication	Phosphate (PO_4 3-, HPO_4-, H_3PO_4, AS P) (W)	NA	g.eq.PO_4
3	CML-Air-acidification	Sulphur dioxide and Nitrogen Oxides (Sox as SO_2 and Nox as NO_2)	0.0001401	g eq. H^+

Limitations:

It should be noted that while LCI enjoys a fairly consistent methodology, the LCIA phase is very much under development and there is no overall generally accepted methodology. However, some principles are becoming increasingly accepted in the LCA community concerning the intrinsic limitations of LCIA:

- **Absence of spatial and temporal resolution** – The normalization of emissions from the system unit operations to one functional unit erases all temporal and geographical characteristics, which are needed to assess local environmental impacts (was the emission instantaneous and localized or spread over a large geographical area over a long period of time?).

- **Absence of threshold information** – LCA is based on a linear extrapolation of mass loadings with the assumption that this loading contributes to an environmental effect. This non-threshold assumption contradicts several environmental and toxicological mechanisms. While this characteristic proves to be a reasonable assumption for impact categories such as global climate change, it counters the impact assessment categories dealing with toxicity (human and ecological toxicity).

Inputs and outputs not assigned to an impact category

- **In Agricultural phase the inputs of land use is not included, because no method for the impact category land-use was available.**

- **All the impacts due to production and processing chemicals used as input to the system are not included**

- **For Lamination unit process, impacts due to LDPE production was not included**

Chapter
6

Life Cycle Interpretation:

Life cycle interpretation includes communication, to give credibility to the results of other LCA phases (namely the Life Cycle Inventory and Life Cycle Impact Assessment), in a form that is both comprehensible and useful to the decision-maker.

The objective of the life cycle interpretation of the present LCA study are to analyse results of environmental impacts identified during three different life cycle stages of selected jute products in order to reach conclusions, explain limitations and provide inputs to formulate the Ecolabel as well as Disposal protocol. As suggested in the ISO document 14043 (1998) the interpretation has been carried out in three steps:

- Identification of the significant issues
- Evaluation
- Conclusions, recommendations and reporting

The first two steps are followed in a recursive process. Conclusions are based on the combined results of the two preceding steps. The following table summarizes the interpretations:

Phase of Life Cycle	Impact	Comments
Agricultural phase or phase I	**IPCC-GHG effect**	**The most significant impact in the Jute life cycle is the carbon sequestration by green jute plants in the agricultural stage. Approximately 4.88 tonne of CO_2 get sequestered per tonne of raw jute fibre production. However, the anthropogenic methane emission from retting pond in case of conventional retting process also contributes to this impact. But the overall GHG emission impacts becomes negative as the jute plantation acts as a sink for carbon.**
Manufacturing Phase or Phase II	**Human Toxicity**	**Uncontrolled use of Jute Batching oil contributes to this impact**
Manufacturing phase or	**IPCC-GHG effect**	**CO_2 emission due to fossil fuel based energy**

Phase of Life Cycle	Impact	Comments
Phase II		generation, purchased electricity and freight
Manufacturing Phase or Phase II	Air acidification	Oxides of sulphur and nitrogen emission from fossil fuel utilized for energy production
Manufacturing phase or phase II	Eutrophication (Total and water)	COD load due to seizing and other processing chemicals contribute to this impact.
Use and Disposal Phase or Phase III	IPCC-GHG effect	If disposing into an unmanaged landfill, anthropogenic methane emission accounts for this impact. Although, when disposing through managed landfill or through waste to energy incinerator, this impact reduces drastically

Chapter
7

Life Cycle Improvement Analysis:

Impacts due to different activities of Jute products throughout the cradle to grave phases of life cycle, that is, its cultivation , production, transportation to end users, use and disposal have been identified and analyzed. Further to this study, the probable alternatives to the flow and systems responsible for the significant impacts are identified and analysed in order to lessen the adverse impacts from a product life cycle.

Phase I, Cradle to Gate Phase (Agricultural Phase):

The jute agriculture in India is labour extensive, less mechanized and hence less polluted. Moreover application of the fertilizers, pesticides, weedicides and other chemicals are very much restricted. Only the retting process has been identified as main contributor to both the local and global impacts.

1. Dose of fertilizer/ manure:

Applicability:

Products	Yarn	Hessian	HFJH	HFJB	FC	JGT (W)	JGT (NW)	Shopping bag
Applicability								

Current Practice:

Often farmers exceed recommended dose in order to obtain higher yields of jute crop. This results in depletion of soil quality and application of increasingly higher dose every succeeding year in order to obtain the same level of yield. However jute is cultivated in a system of crop rotation. The roots of previous crops and jute itself after harvesting that are left in the field act as fertilizer along with farmyard manure. Thus the overall impact on soil quality because of the use of fertilizer is not very significant.

Suggested practice:

Farmers should be educated in use of recommended doses of urea and at the same time encouraged to use only farmyard manure and biomass attained by rotting leaves and other plants.

2. Use of chemical pesticide in Jute cultivation:

Applicability:

Products	Yarn	Hessian	HFJH	HFJB	FC	JGT (W)	JGT (NW)	Shopping bag
Applicability								

Current Practice:

Common insecticides used are Pyrethoid cypermethrin, BHC, Endosulfan, Metasystonand Kelthane. the amount of active chemicals which are normally used as pesticide are:

Endosulfan : 150-525 ml/ha

Metasyston : 200 ml/ha

Kelthane 1100 ml/ha

Suggested practice:

The recommended dosages are as follows:

Sr. No.	Name of pesticide	Recommended dose per liter	Comments
1	Endosulphan 35%	2 ml	750 ml/ha does is required Dose varies according to the growth of plant Pesticide should be sprayed equally by using sprayer
2	Quinalphos 25 EC	2 ml	
3	Carbosulphan 25% EC	2 ml	
4	Dichlorophos 76EC	0.75 ml	
5	Lindane 20%	2.5 ml	
6	Lindane 6.5% (water based)	5 gm	
7	Ethion 50%	1.0 ml	

(Reference: Instruction manual to Jute cultivation, issued by Govt. of West Bengal,2000)

3. Retting Process:

Applicability:

Products	Yarn	Hessian	HFJH	HFJB	FC	JGT (W)	JGT (NW)	Shopping bag
Applicability								

Current Practice:

Conventional Jute Retting method is basically Steep Biological Method. The conventional method of jute retting contributes towards anthropogenic methane emission is 0.0183 kg/kg of raw jute processed.

Suggested Practice:

The following alternatives are thought proper to reduce the emission during the retting process

- Mechanical retting process reduce the methane emission to some extent by reducing the total time required for retting. NIRJAFT developed a machine that can handle 120-200 kg stems/hr and can be run by a motor of power 1 HP to 2 HP. Mechanical treatment by the machine is very mild which does not affect the physical properties of the fibre bundle. There is an improvement of fibre quality and net return.

- Chemical retting process : More controllable retting procedures to produce quality fibers from jute are sought by applying chelators at high pH and enzyme-chelating formulations at lower pHs. Using the Fried Test as an in vitro method for evaluating fiber separation, EDTA (ethylenediaminetetraacetic acid) at 8-mM levels and sodium tripolyphosphate at 50-mM levels, both with h25mM NaOH, effectively retted jute stems. Chemical retting was influenced by chelator type and level, sodium hydroxide levels, and plant condition and maturity. These factors plus resultant fiber properties require consideration in optimizing chemical retting with chelators at high pH. In chemical retting process, stalks are processed using chemical agents to dissolve the lignin. This process can reduce retting period to 48 hours and produce a high quality fibre. The lignin extracted from fibre, as a byproduct can be further utilized to produce lingo sulphonate which has been widely used as a dust suppressant on unsealed roads.

Phase II: Gate to Gate Phase (Manufacturing Phase):

For different jute products, the impacts are different. For every jute products the possibility of current and improved practices are presented as follows:

4. Use of batching oil in the softening process:

Applicability

Products	Yarn	Hessian	HFJH	HFJB	FC	JGT (W)	JGT (NW)	Shopping bag
Applicability								

Current Practice:

JBO is being used as batching oil in the softening process. Hydrocarbon contamination from jute bags has been traced to the use of JBO in the batching process. JBO is non biodegradable.

Suggested practice:

Replacement of JBO with that of RBO has eliminated the impact due to presence of hydrocarbons. RBO processing is costlier but the premium received on RBO treated bags offsets the cost disadvantage.

5. Steam generation

Applicability:

Products	Yarn	Hessian	HFJH	HFJB	FC	JGT (W)	JGT (NW)	Shopping bag
Applicability								

Current Practice:

Usually jute mills use fossil fuel viz. coal as fuel to the boiler for production of steam. This practice has adverse environmental impacts like GHG emission, air acidification and natural resource depletion.

Suggested Practice:

The adverse impacts can be eliminated by using biomass as fuel. Jute caddies generated during processing are suitable for using in this purpose. Additionally rice straw , bamboo chips or any relevant biomass may be used as replacement for coal.

6. Use of Electricity:

Applicability:

Products	Yarn	Hessian	HFJH	HFJB	FC	JGT (W)	JGT (NW)	Shopping bag
Applicability								

Current Practice:

Inefficient use of electrical energy not only increases cost of production but also result in higher degree of GHG emission and natural resource depletion.

Suggested Practice: It has been noticed that the improvements to be carried out in respect of the feeder and cable system of the distribution network, lighting load, power factor correction, rearrangement of driver and maintenance of machines. The suggested practices are as follows:

- Establishment of an energy management program in each mill

- The capacity of the motor in the spinning section may be optimized. The machines running with 15 HP motors are found to have better efficiency compared to 20 HP rated motor driven machines. Similarly 15 HP motors connected to slip draft machines may be replaced by 12.5 HP motors to obtain better efficiency.

- Usually the machines in the spinning and weaving section have individual drives whereas carding and weaving machines in some mills also have group drives. The rating of the group drive motor is invariably more than the connected load. In some cases the loading is as low as 40 % of the rated motor power. The efficiency of induction motors at such a low load is very poor. Accordingly the loading of group drives must be improved to get energy efficiency.

- Usually the power factor correction is being obtained at the bus. The no load current of various drives can be reduced by installing capacitors at the drive terminals. This will also reduce the cable losses in addition to achieving the reduction in no load current.

- The distribution network inside the mill should be restructured. There is scope for achieving reduction in cable losses by locating the transformers at load centers and use of a single cable of higher capacity and proper size rather than connecting additional loads to shops through additional cables.

- The existing practice of partial rewinding of motors by replacing only the burnt –out coils must be discontinued. Complete rewinding of the motors must always be undertaken in order to avoid imbalance among the phase currents.

- Idle pulleys on group driven shafts cause power loss and should be removed.

- Some heavy load like pumping etc. must be redistributed to the low demand period

- Substantial amount of electricity savings may be achieved by replacing conventional chokes by electronic chokes in light fixtures.

- Regular cleaning of machines must be undertaken in order to reduce the power consumption of the machines

- In case of fan cooled motors the replacement of fan impeller is being done with locally made impellers which are heavier than the original. This practice leads to higher power consumption and must be discontinued. The replacement must always be done with impeller of correct weight.

- The spinning section of a jute will alone consumes about 35% to 40% of the energy consumed in production.

- The slip draft spinning frame running with 15 HP motor ban be replaced by 12.5 HP motor for spinning 8-12 lb yarn running at 4000 rpm.

- Wide fluctuations in voltage must be regulated to reduce higher consumption of energy

- maintenance of the frame and motor must be improved in order to reduce the running current. Particular attention must be paid to the conditions of the flyer cylinder and pressing roller

- capacitors should be introduced to improve power factor. The capacitors may either be mounted on control switches of the spinning frame or capacitor banks may be installed in the switch room.

7. Use of Batching and Seizing Chemicals:

Applicability:

Products	Yarn	Hessian	HFJH	HFJB	FC	JGT (W)	JGT (NW)	Shopping bag
Applicability								

Current Practice:

- Use of Non ionic emulsifier (Long chain EO adducts) as Batching Chemicals
- Use of Synthetic starch or Tamarind Kernel powder (50% BOD) as Seizing chemicals

Suggested Practice:

- Use of Non ionic emulsifier (Short chain EO adducts) as alternate Batching Chemicals
- Use of Carboxymethyl cellulose or polyvinyl alcohol (1-3% BOD) Depolymerised starch or etherified galactomanon polysaccharides as Seizing chemicals

8. Use of Bleaching and Dyeing Chemicals:

Applicability:

Products	Yarn	Hessian	HFJH	HFJB	FC	JGT (W)	JGT (NW)	Shopping bag
Applicability								

Current Practice:

- Use of Anionic detergent (branched alkyl or aryl anionics) as Scouring chemicals
- Use of Bleaching powder, sodium silicate as Bleaching agent
- Use of Kerosene in pigment printing

Suggested practice:

- Use of Anionic detergents (linear alkyl anionics) or by enzyme as Scouring chemicals
- Use of Hydrogen peroxide, organic peroxide stabiliser as Bleaching agent

- Use of Aqueous pigment binder in pigment printing

9. Process modification for reduction of pollution load:

Applicability:

Products	Yarn	Hessian	HFJH	HFJB	FC	JGT (W)	JGT (NW)	Shopping bag
Applicability								

Current Practice:

- Scouring, bleaching and Dyeing processes have been operated separately
- Water consumption in dyeing process is huge.

Suggested Practice:

- Combined scouring and dyeing
- Simultaneous bleaching and dyeing
- Use of standing bath in dyeing
- Use of high exhaustion/ fixation dyes and dyeing methods
- Reuse of wash water from subsequent washing to the previous washings

10. Presence of dust during manufacturing and use of jute products:

Applicability:

Products	Yarn	Hessian	HFJH	HFJB	FC	JGT (W)	JGT (NW)	Shopping bag
Applicability								

Current Practice:

The processing of jute generates a considerable volume of dust. A 100 Tonne per day production will generate about 4 Tonne per day of jute dusts. Normally this dust is recycled into the boiler. The dust, if not properly removed, may cause breathing problems for workers. The carding operation produces the maximum volume of dust. Furthermore, the dust finds its way to the finished product and may cause human toxicity to the users.

Suggested practice:

All modern machines like cards, spreaders and spinning frames now incorporate dust extractors to eliminate this problem

11. Lamination of the jute shopping bag:

Applicability:

Products	Yarn	Hessian	HFJH	HFJB	FC	JGT (W)	JGT (NW)	Shopping bag
Applicability								

Current Practice:

Generally plastic or LDPE is used for lamination process

Suggested Practice:

Latex based lamination process is suggested

Chapter
8

Conclusions:

This present LCA study was carried out to identify the major environmental impacts throughout the jute life cycle on cradle to grave basis that is starting from agricultural production of jute, processing of jute raw material, manufacturing of jute products upto use and disposal of jute products. As depicted in the following table, the result of interpretation has been utilized as inputs to formulate Ecolabel as well as disposal protocol.

Life Cycle Phase	Impacts Identified	Criteria developed
Phase I	GHG emission due to methane generation from retting process	The retting should be non-conventional retting such as ribbon, chemical or mechanical. If conventional retting is used, the retting ponds should not be sources of drinking water or fishing and they should not be more than 1 m deep. Otherwise, to ensure that COD of wastewater after retting be at least 95% reduced and methane generated has to be collected and flared or utilized for energy.
Phase I	Impacts due to excessive use of pesticides	Jute fibres must also not contain more than 0,05 ppm (sensibility of the test method permitting) of each of the following substances: Aldrin, captafol, chlordane, DDT, dieldrin, endrin, heptachlor, Cypermethrin, hexachlorobenzene, hexachlorocyclohexane (total isomers), 2, 4, 5-T, chlordime-form, chlorobenzilate, dinoseb and its salts, monocrotophos, pentachlorophenol, toxaphene, methamidophos, methylparathion, parathion, phosphamidon, If standard quantities prescribed by the Government of India are followed, then this criteria condition is achieved, provided these are not banned chemicals in the intended market.
Phase II	Eutrophication (water) due to presence of high PO4 content.	Detergents, fabric softeners and complexing agents: At each wet-processing site, at least 95% by weight of the detergents, at least 95% by weight of fabric softeners and at least 95% by weight complexing agents used must meet the requirement for ready biodegradability
Phase II	Human toxicity	The heavy metals as mentioned in the table in the ecolabel protocol may not exist in amounts higher than as specified for finished jute products other than food grade quality jute sacking or hessian textile products.
Phase II	Eutrophication (water) due to presence of COD	Waste water from wet-processing sites like batching and piling process, bleaching and dyeing process shall, when discharged to surface waters after treatment (whether on-site or off-site), have a COD content of less than 25 g/kg, expressed as an annual average.
Phase II	IPCC GHG emission	Requirements as to energy and resource consumption: At least 20% of the fuel consumption for steam generation should be of renewable energy sources like jute caddies, rice husks, biomass etc.

Phase II	**IPCC GHG emission**	**Requirement as to CO2 emission factor during transportation: the emission factor should not be more than 0.007 kg CO2/tonne-km in case of transportation of products by sea. For road transportation, the vehicles to be used should conform to the pollution under control (PUC) regulations under the Motor Vehicles Act in India.**