Final Report

SP1214 Coir: a sustainability assessment

Dr Lisa Drewe

Newleaf Sustainability Practice

Start date: 1/02/12

End date: 31/05/12

CONTENTS **PAGE**

LIST OF ILLUSTRATIONS **PAGE**

ACKNOWLEDGEMENTS

Our special thanks to Tom de Vesci, Project Sponsor and Managing Director, Horticulture Coir for his invaluable insight in to the coir industry and for his personal support of the project.

The following people, their companies and institutions are gratefully thanked for all of their information and time given to supporting this study. The views in the report are however entirely those of the authors.

Predeep Adikari, General Manager, Greensoils, Sri Lanka.

Hein Boon, Managing Director, RHP, Netherlands.

David Buchanon, Renewable Energy Professional, UK

Kalum and Samantha Balasuriya, Managing Director/Director, Botanicoir, Sri Lanka.

Dr Robert Carlton,Owner, Carlton Consultancy, France.

John Chacko, Chairman, Federation of Indian Coir Exporter’s Association; Indian Coir Board member; and Director, NC John and Sons, Ltd., India.

Vinay Chand, Owner, Vinay Chand Associates.

Mathew Dent, Managing Director, Fertile Fibres, UK.

Riyaz Dhalla, Senior Food Technologist, Waitrose, UK.

Coconut Development Authority, Sri Lanka.

Robert George, Technical Manager, Soils Association, UK.

Elaine Gotts, Manager, International Product Development - Growing Media, The Scotts Company, R&D, UK.

Sonali Gunasekera, Poor Women’s Economic Leadership Programme Advisor, Oxfam (GB).

Tharanga Gunasinghe, Programme Coordinator, Poor Women’s Economic Leadership, Oxfam (GB).

Coconut Research Institute, Sri Lanka.

Dr Hugh Harries, Coconut Timeline.

Prof. Mary Helen, Nagercoil University, India.

Dunston Joseph, Managing Director, Sivanthi Joe Group, India.

Mahesh Kumar, President, Coir Pith Association and Managing Director, Sunco Exporters Pvt., Ltd, India.

Andrea Marshall, Technical Marketing Manager, William Sinclair Horticulture Ltd.

Dr T Monoharan, WWF, Global Forest Trade Network, India.

Sajan Nair, Secretary General, Federation of Indian Coir Exporterôs Association, India.

Dr Ram Ramakrishnan, President, Sai International Trading Crop., USA.

Dr Jamie Robinson, Technical Director, Westland Horticulture.

A. Santhanam, Managing Director, Sai Cocopeat Export Private Ltd, India

Charith Senanayake, Managing Director, Rainforest Rescue International, Sri Lanka.

Marcel Silvius, Wetlands International.

K. Sivakar. Marketing Director, Sivanthi Joe Group, India.

Coconut Research Institute, Sri Lanka.

Dr Lex Thompson, EU-FACT Team Leader, Agri-forestry Export Production Specialist, Fiji Islands.

G. Udayakumar, Owner, Bloom and Peat, India.

Dr Hillary Young, Ziff Environmental Fellow 2011 - 2013, Harvard University, USA.

GLOSSARY

Brown husk ï husks from mature coconuts. Can be processed dry to produce brown fibre which is used to make rubberised coir, geotextiles, car seats and brushes etc.

Coconut husk - made up of the exocarp and mesocarp. The exocarp is the outermost layer and the mesocarp is composed of fibre known as coir. Coir fibre and pith are derived from processing the mesocarp.

Coconut shell ï the tough outermost layer of the endosperm, or white flesh, of the coconut.

Copra ï dried coconut flesh. The coconut flesh is also known as the endosperm.

Decorticator ï a machine that peels off the husk of the coconut. The decorticator is used for the dry processing of coir. Coir is extracted from fresh husks, green husks, or husks that have been soaked for a few hours. The husks are fed in to the machine and mechanically beaten against a cyclindrical cage. This machine does not produce long fibres and the fibre output for husk is generally lower. Only mixed grade fibres are produced.

Defibreing machine ï this machine is more efficient at separating fibres than the needle drum and is also safer for users. It is the system that makes mattress fibre. The husk segments are gripped at the periphery of a large wheel by another wheel placed eccentrically, so that the gap reduces as the husk moves towards the picker drum. The needles of this drum removes the fibres and pith, leaving the bristle coir. The first drum defibres half of the husk segment, which is then transferred to a second wheel while the defibred part of the husk is held by the conveyor chain. The defibring is then completed by the second picker drum. The quality of fibre obtained from this machine is poor and it needs to pass through a cleaner drum or wash to remove the pith adhered to the fibres.

The D-1 machine is a hybrid of the needle drum and the defibring machine and was developed in Sri Lanka. It is known as the modified decorticator. The nail drum acts as the opener and the husks are fed through the rollers. Unlike the needle drum it is not necessary to hold the husks manually for the fibre bundles to be combed out. The pith and the fibres are partially removed by the nail drum, and then automatically transferred to a section similar to the decorticator for further removal of pith by mechanical beating. The machine is capable of using green husks, retted husks or wetted husks and produced mixed fibres that are superior to the fibres extracted from the decorticator alone.

Endocarp ï the coconut shell

Extensive agriculture ï in contrast to intensive agriculture, extensive agriculture uses relatively low levels of labour and capital per area of land.

Geotextile ï polymer fabrics, that can be based on natural materials, used in the construction of roads, drains, harbour works, land reclamation, erosion control.

Green husk ï husks from immature coconuts. Are generally soaked in water, through a process known as retting, prior to fibre extraction to make white fibre which is used to produce mats, nets etc.

Home garden - land use systems involving the deliberate management of multipurpose trees and shrubs in intimate association with annual and perennial agricultural crops, and invariably livestock, within the compounds of individual houses which is intensively managed by family labour.

Inorganic fertilizer ï manufactured fertilizer from raw materials such as fossil fuel and phosphate rock.

Intensive agriculture ï system of cultivation that uses high level of labour and capital inputs relative to land area for the application of fertilizer and pesticides, mechanisation of planting, cultivating, harvesting and irrigating.

Kernel ï the white meat of the coconut.

Needle drum ï (also known as the Ceylon drum)a traditional mechanical device for the extraction of coir fibre. This machine has two sets of wheels with needles on the circumference to comb the retted husk and extract the fibres. The first drum, the breaker drum, has a set of needles that are course and serve to remove the exocarp. The husk segments are first fed to the breaker drum by hand. The second drum, the cleaner drum, has needles that are finer to remove the shorter fibres.

Organic fertilizer ï fertilizers produced from organic plant or animal matter.

Retting ï a process utilising the duel effects of water soaking and the action of micro-organisms to break down the cellular tissue of fibres this facilitating the separation of fibres in the coconut husk. During retting coconut husks are bundled, weighted and placed in water for a period of time.

Natural water sources, such as stagnant or slow moving rivers, ponds, bogs and the ocean can be used. Retting in man-made tanks made of concrete may also be adopted and treated waste-water does have beneficial properties as a liquid fertilizer and for irrigation.

Retting zone ï an area of river, lagoon or coast where extensive retting activity takes place

Rubberised coir ï mattress fibre pads sprayed with rubber latex which bonds the fibre together.

EXECUTIVE SUMMARY

Summary

Defra's recent consultation paper on reducing peat use in horticultural markets resulted in a strategic policy framework and ambition outlined in the UK's Natural Environment White Paper (2011) to phase out peat use by all gardeners, growers and procurers by 2030 at the latest, through switching to more sustainable peat free alternatives. The Sustainable Growing Media Task Force (SGMTF) was formed to identify how to overcome the barriers to achieving this without adversely affecting commercial operations or the productivity and satisfaction of UK growers and gardeners. The SGMTF's remit was also to understand the sustainability of alternative materials to ensure that one inherently unsustainable material is not replaced by another.

This project undertook a sustainability assessment for coir pith and its supply chain. The approach was firstly to map the UK coir pith supply chain and to identify all stages, processes and actors within it. Then to understand the potential environmental, ethical and economic impacts through a literature survey followed by an investigation of the coir fibre and coir pith industry in India and Sri Lanka. Sustainability hotspots were identified using a simple risk matrix that also took in to account the relative proportion of impact that could be attributed to coir pith during coir pith processing, coir fibre production and coconut production.

The study established that the sustainability hotspots for the coir pith supply chain were the working conditions, water consumption and pollution for coir pith processing and working conditions in coir fibre mills. The latter requires more leadership from the coir fibre industry to address.

Retting is a significant environmental issue but it's presence or absence in coir pith supply chains will vary according to the fibre extraction method that the coir pith is derived from. It is certainly incorrect to assume that retting is used in every supply chain.

The study also established what good practice looked like for many of the sustainability indicators used. The generic conclusions are based on the industry as a whole. They do not apply to every supply chain, each of which would have to be assessed individually to understand their specific impacts. The impacts vary between country and business and according to how much of the impact can be allocated to coir pith.

Suggestions are made to address the impacts of coir pith processers and how the coir pith processors can address significant issues within their supply chains.

Background

Coir pith is the corky material found between the fibres in the husk of a coconut. Once harvested the whole coconut is separated into kernel and husk, where the kernel is used either directly as food or processed further into food products or oil. The coconut shell itself is also an economically important commodity when converted to carbon and activated carbon for use in water and air filtration systems. The husk goes to fibre mills where the coir fibre is extracted. The by-product of this process is coir pith. The coir fibre industry in India and Sri Lanka is long established. For many years coir pith was the waste product of the extraction process and was dumped outside of coir fibre mills, generating large environmental pollution issues of its own. It is only over the last 20 years or so that the coir pith, has been utilised. In the early years the coir pith was generally of a variable quality and unfit for use by the horticultural sector. Today with an economic value almost equal to fibre for high quality pith that has all changed.

Availability and quality

The very strong global markets for coir fibre products and the increasing utility of coir fibre in new products ï such as mattress, geotextiles and products for the automotive industry ï means that coir fibre processing is an abundant activity in coir producing nations; the largest of which are India and Sri Lanka. The utilisation rates of husks are increasing to support this, with Governments in both countries looking to incentivise and promote this further.

As a by-product of coir fibre, coir pith is therefore also in abundant supply. Even with competing markets for quality coir pith in Europe, USA and Australia enough pith is potentially available to supply the demands of the markets. The coir pith industry is certainly more organised than has been the case in the past, which is set to further improve with time. Pith trade associations are common in the main processing areas. They are keen to raise standards and to self-regulate the industry to maintain the export of quality products. The Sri Lankan Government has drafted standards for coir pith exports and, in time, hope to make these mandatory as well as test product quality. That said, there are still many processors with low quality pith. As with all other product categories UK procurers need to build assurance mechanisms in to their procurement processes to keep such sources out of their supply chain.

The UK is already being supplied with a large volume of high quality coir pith from both India and Sri Lanka, although few source directly from the processors and many rely on the services of importers to guarantee quality and consistency.

Sustainability assessment

A sustainability assessment was designed to establish the sustainability hotspots in the coir pith supply chain.

The three tiers in the supply chain identified were as follows:

- Tier one ï coir pith processing
- Tier two ï coir fibre production
- Tier three ï coconut production.

The following sustainability indicators were developed to assess each of the three tiers: availability of raw materials, quality of materials (to deliver to UK growers specifications), economic, biodiversity, land use change, pollution of water, soil and air, water consumption, energy consumption, cultural significance, rural economy and working conditions.

A straightforward risk matrix and scoring system, identifying likelihood and severity of impact, was used to understand the significance of the impacts. In terms of attributing impacts to coir pith an economic and volume allocation method, similar to that of LCA methodology for by-products, was used. Using this methodology coir pith was found to be responsible for 100% of the impacts of coir pith processing (once removed from the coir fibre process); up to 50% of the impacts of coir fibre processing; and 5% of the impacts in the coconut plantation.

Sustainability hotspots for the coir pith supply chain were determined using this simple scoring system. Out of a possible range of scores from -9 to +9, those areas of the supply chain scoring -4 and lower were considered to be sustainability hotspots.

The information used to inform the sustainability assessment was derived initially from a literature review. The findings were verified and further information was collected through on site visits in India and Sri Lanka. Visits were made to coconut plantations, coir fibre mills, coir pith processors, every type of retting scenario, senior government officials, scientists and environmental and social NGO's. The visits were not designed to conduct environmental or ethical audits within specific businesses but to develop an insight into the coir pith industry as a whole.

The levels of management information such as written policies, procedures, records of employment, deliveries of inward and outward goods varied enormously from one business to another. Variations in environmental and ethical impacts were also found to differ significantly between factories and between each country. The results in this report can only be presented from a generic perspective. To understand the impacts in a specific supply chain that supply chain would need to be looked at separately.

Key findings

The sustainability assessment identified the following sustainability hotspots:

Tier 1: Coir pith processing.

- Water consumption

Water is used in coir pith processing to wash and sometimes buffer the coir pith to remove the salts. It is an essential process to assure quality pith for the UK horticultural market. In India the main coir pith processing areas are in Tamil Nadu, which is a State that suffers water stress and scarcity. Although practices to conserve water were observed this was not the norm. Few pith processors had water management practices in place.

The challenge is not so significant in Sri Lanka which has less of an issue with water availability in the key coir pith producing areas. That said, water management is always suggested throughout the industry for both countries in this study.

- Working conditions

Dried coir pith is a small, very lightweight material. It is easily carried in the air. Every factory visited had an issue with dusty working conditions, some were considered extreme whilst others undertook good manufacturing practice by keeping floors and machinery free from dust. This had a big impact on the air quality. Many factories provided dusk masks for employees. Although this helped, the use of personal protective equipment (PPE) did not remove the issue of excess dust in these sites. Wearing of PPE was also very uncomfortable in conditions of very high temperatures and humidity. Some factories had plans to adopt new practices and innovations to remove more dust from the work area in the future.

A few coir pith processors had undertaken a formal ethical audit either on a voluntarily basis or on behalf of their customers. Unfortunately this was not the norm and so independent scrutiny of wages, working hours etc had not taken place. Most of the facilities visited operated at least a 6-day week with multiple shifts, which presents a higher risk for potential labour issues and a need for greater transparency of ethical management practices. Both India and Sri Lanka have adequate labour legislation for the formal, industrial sector. Where coir pith processors fall in to the formal sector the risks are likely to be much lower as government authorities do regularly inspect sites to assure compliance.

The greatest risk is seen to be with the smaller coir pith processing units that fall in to the informal sectors and so are unlikely to be inspected by the Government to identify and rectify bad ethical practices. The identification of the relative proportion of the coir pith supply chain that falls in to the informal sector would be the subject of a further study. It is certainly a very important area to address in any future assessment of specific supply chains.

- Water and soil pollution

As discussed above, large volumes of water are used to wash (and buffer) coir pith. This is generally achieved by hosing or spraying water over mounds of coir pith placed either directly on soil or on concrete floors. The run-off from these processes will contain high salts, chemical, microbial and physical contaminants. If the run-off is untreated it will contaminate surface water, groundwater and soils. The issue can be resolved by washing on concrete floors, collecting the run-off and treating the effluent, which was observed in some of the factories.

Other sustainability indicators in Tier 1 (coir pith processing) that were not classified as sustainability hotspots using the methodology adopted for this study still registered challenges that need to be addressed in the future.

Tier 2: Coir fibre production

According to volume and economic allocation methodology less than 50% of the impacts of coir fibre production can be attributed to coir pith. This may appear to be a slightly unfair figure to some with a valid argument that coir fibre processing is designed purely to achieve the right quality of fibre and the best productivity in its extraction. Coir pith is still very much viewed as a waste product in India and Sri Lanka.

The sustainability hotspot for the coir pith industry to address was working conditions.

- Working conditions

The working conditions in coir fibre mills varied according to country and degree of mechanisation. In India, where the process was mechanised the health and safety aspects were generally reasonable, although a proper assessment would always need to be made for individual factories.

In Sri Lanka, which uses the more traditional processes, the health and safety conditions were concerning. Of particular note is the prevalent use of the spinning nail drum which is generally used without any hand guards or other safety features in areas which have unrestricted access.

The International Labour Organisation (ILO) undertook a study of working practices in coir mills in Sri Lanka with the support of coir mill owners and officials of the Coconut Development Authority and the Industrial Technology Institute. As a result "100 Good Working Practices – Guidelines for Coir Mills[1]" was published outlining how coir mills can adopt better working practices. The Government of Sri Lanka are very aware of the issues and are working with the industry to improve them through the development of model mills, ongoing education programmes and investment.

Although the impacts in coir fibre extraction certainly raise some very big questions for the supply chains of coir fibre in the UK, it would be unfair to expect the pith supply chain to solve many of the issues without the leadership of the fibre industry and the Government's in these countries.

The issue of retting

Retting is viewed by other researchers as one of the most significant impacts in the coir pith supply chain[2]. Coir pith can however be produced without this process, For example, the mechanised husk processing systems widely adopted in India, and increasingly in Sri Lanka, for the production of mattress fibre does not require the retting process at all. Where retting is used in certain fibre production systems the longer term soaking and microbial action is a requirement for the production of coir fibre and not coir pith.

Traditional retting means the soaking of husks for up to 9 months in water and is part of the traditional coir fibre extraction industry in both India and Sri Lanka. This process has rightly received much attention because it is so environmentally damaging.

The most significant finding of this study though is that it is very unlikely that coir pith from the traditional 9 month retting (soaking) process enters supply chains for the UK. There are a number of reasons for this. The first is that, in terms of coir pith extraction, it is very inefficient as much of the pith is washed from the husk and sediments at the bottom of the retting pits or is washed away. There are also significant quality issues with pith recovered from this process as it will be of high salt content if soaked in salt or brackish water. After 9 months soaking the pith has also expanded irreversibly and so will have lost many of its physical benefits. Finally, this extended retting activity tends to take place in the traditional coir fibre areas of India and Sri Lanka which are distant from the high volume pith processing areas for the horticultural markets. Rising fuel costs in both countries would make the transport of such material unviable.

There is however a 2 month retting process for brown husks that is quite widely used in Sri Lanka. Although the environmental impact should be much less that 9 month retting there

[1] http://www.entergrowth.com/download.php?type=projects&id=68

[2] Comparative lifecycle assessment of horticultural growing media based on peat and other growing media constituents. 2012. http://www.epagma.eu/default/home/news-publications/news/Files/MainBloc/EPAGMA_Growing-media-LCA_Final-report%20_2012-01-17_Quantis.pdf

will still be an impact on the environment, particularly if the water is not flushed through and the effluent is not treated. In Sri Lanka, the Coconut Development Authority (CDA) are promoting the use of concrete tanks to control the impact and to minimise soaking time. There was also anecdotal evidence that the more responsible fibre mills flush the water in these tanks regularly to reduce impacts. The CDA is also promoting the use of mechanised systems similar to those in India to increase productivity and to supply the Chinese coir mattress market in which case the process of retting will become obsolete for the majority of the high volume fibre production.

Tier 3: Coconut plantation

No sustainability hotspots for coir pith was found in the production of coconuts. Coir pith is assessed to be responsible for only 5% of the impacts in a coconut plantation. The coconut has huge religious and cultural significance in the countries of interest. Every part of the tree is used either for sustenance or income and so, for the rural economy, the coconut crop is critical. It is also a crop that does not intensively use land and so other crops can be planted with it, bringing further environmental and economic benefits. The coconut is grown first and foremost as a food crop.

The only impact worthy of note at this stage is the requirement for irrigation of the coconut palm, particularly in the water stressed areas of Tamil Nadu. Water conservation practices need to be implemented. Because of the deforestation issues associated with the palm oil industry in Indonesia and the Philippines, land use change was explored in terms of the coconut palm. No evidence of recent detrimental land use changes, or plans for future changes, in India and Sri Lanka were found. This is however considered a risk for new coconut plantations in Indonesia and the Philippines. Supply chains in these regions would need to establish full traceability to assure that the source of raw material was not a sustainability issue.

Conclusions

The main conclusions from this study are that the coir pith supply chain brings significant positive benefits in terms of supporting the rural economy in India and Sri Lanka. Availability and quality of coir pith in both countries can satisfy the future needs of the UK horticultural sector, particularly if the sector is prepared to work more in partnership with their suppliers.

The sustainability hotspots for the coir pith supply chain are:

- Tier 1 (coir pith processing) ï water consumption (particularly in Tamil Nadu) and pollution of water and soil linked to the washing and buffering process; and the working conditions in coir pith factories.
- Tier 2 (coir fibre processing) ï working conditions, particularly in Sri Lanka.

There are clearly other sustainability issues throughout the supply chain but the relative proportion of these that can be attributed to coir pith is much lower and other sectors need to also recognise and address them. The key environmental concern in this category is retting. The retting process is not a requirement for pith extraction and this element of the fibre extraction process has largely been phased out in India for the high volume coir mattress fibre industry. Mechanised fibre extraction results in more productive harvesting of coir pith. Where higher volume pith processing occurs in regions with high levels of mechanisation, such as Tamil Nadu, retted material is therefore less likely to enter the pith supply chain. Retting does however remain more of a concern in Sri Lanka where there are lower rates of mechanisation. The Sri Lankan Government is aware of the issues and is addressing them at pace through education, model mills and financial support.

The Tier one sustainability hotspots can be directly addressed by the UK coir pith supply chain. This supply chain also has the opportunity to play a role in addressing the environmental and ethical practices within the fibre mills.

Suggestions

The following suggestions are made:

- The key sustainability hotspots for the coir pith supply chain should be directly addressed by the coir pith processors with the support of their customers and governments. UK growing media manufacturers and growers should request that the coir pith processors in their supply chain undertake an independent and internationally recognised ethical audit to address key concerns identified through this study. Audits should use existing guidance such as those recommended by the International Labour Organisation. Pith processors should work closely with their main sources of pith to ensure that improvements are made in the working conditions of fibre mills. This will ensure that the rural economy fully benefits from the growing coir pith industry rather than continuing to work in conditions that have been described as óappallingô and óunsatisfactoryô by the ILO when talking of the traditional coir fibre mills. Water management practices in pith processing is very important to address whether the pith processing is undertaken by a coir fibre mill or by the pith exporter. This should critically address the consumption and conservation of water and the treatment of the effluent from washing and buffering.

Coir pith processors also have the opportunity of supporting the coir fibre extraction industry address its key sustainability issues, namely 2 month retting and the working conditions in the fibre mills.

- As some of the major environmental and ethical impacts are concerned with **coir fibre** supply the coir fibre supply chain in the UK should be made aware of these impacts and how to address some of the key issues, in line with their responsible procurement policies. Certain horticultural coir pith products are specified to contain short coir fibres, however this fibre is the sieved fibre from coir pith processing industry and is not assessed to change the apportioning of impacts to the coir pith industry.

- UK growing media manufacturers and growers should request traceability of their materials as a pre-requisite for their coir pith suppliers to source their raw material from coir fibre mills that undertake responsible ethical and environmental practices. As has been previously discussed the presence or absence of retting from a supply chain needs to be determined and addressed for each supply chain and coir pith processors can play a big role in this.

- Retailers of coir pith products should ensure that they embed their ethical and sustainable procurement policies into the coir pith supply chain.

1. Project aims and objectives

The overall aim of the project is to provide the SGMTF with a robust and credible evidence-base to assess the sustainability issues that currently relate to coir pith production and provide guidance to UK growing media manufacturers and growers to support their procurement of responsibly sourced coir pith.

The project has the following objectives:

- Map the UK coir pith supply chain and identify all stages, processes and actors involved.
- Undertake an inventory analysis to determine the inputs and potential impacts at each stage of the supply chain
- Undertake an initial literature review to understand the potential sustainability hotspots, or risks, at each stage of the supply chain
- Undertake an on-site sustainability assessment to understand the sustainability hotspots for coir fibre mills, coconut producers and coir pith producers
- Understand what best practice in coir pith supply chains looks like
- Identify countries and regions with the greatest potential to supply responsibly produced coir to the UK

2. **INTRODUCTION**

The introduction provides the methodology used to undertake the sustainability assessment. It describes the UK supply chain for coir pith and the key actors, linkages and traceability. Full background information is provided for each tier of the supply chain and the legislative context for the two countries studied, India and Sri Lanka, is provided. The material used in the introduction is a result of literature surveys, on-site assessments and interviews with key stakeholders in the UK coir pith industry, importers, Government officials and scientists in Sri Lanka and coconut growers, coir fibre producers and coir pith processors in India and Sri Lanka. The information is provided to support the development and interpretation of the findings of the sustainability assessment.

2.1. Coir pith

It is firstly important to understand what coir pith is.

Coir pith is a by-product of the coir fibre processing industry. The outer husk of a coconut is made of fibrous material and the coir pith is the corky material that is found amongst the fibres (figure 1).

Figure1- Whole coconut showing the white coconut meat,dark surrounding shell and the outer husk. The husk is made up of fibrous material and the pith is the corky material that can be seen amongst the fibres.

The husk is removed from the coconut kernel (figure 2) ï the coconut that we usually see in our supermarkets ï and the coir fibre is extracted for weaving and making twine and rope.

Figure 2 – Outer husks of the coconut from which coir fibre and pith is extracted.

Once it has been separated from the fibre, coir pith is a brown, saw-dust like material (figure3).

Figure 3- Coir pith after separation from the coir fibre and initial stages of processing. The content of remaining fibre depends on the final use of the coir pith product.

Physically, coir pith is a very light and compressible material. It is highly hygroscopic and has good water holding properties.

With a structure similar to peat it can be used as a 100% peat free material to grow many plants such as houseplants and conifers and is widely used in soft-fruit production and other horticultural crops. It is also mixed with other materials as a peat diluent, especially wood fibre and green compost. It is used in horticulture as a soil conditioner, surface mulch/rooting medium and desiccant.

It is processed into many different products for the horticultural sectors. It can be compressed (6:1) into varying size blocks (600g ï 5kg) to enable the export of large volumes of pith for formulation by growing media manufacturers overseas (figure 4). It can also be processed and compressed (4:1) into grow bags for direct use by large-scale growers who benefit from a product that lasts 1-2 years longer than a traditional peat based grow bag. These products are made to a high specification where the physical and chemical properties have been carefully managed to produce a finished product for a very demanding growing situation. Coir pith has an ability to be compressed into a wide range of added value products such as seed cells, propagation modules all the way up to bagged coir pith blocks that when hydrated fill a specific volume for home growing.

Figure 4 - Processing of coir pith blocks for export to overseas markets.

2.2. Sustainability assessment

The sustainability assessment developed for this study has adopted certain aspects of the ISO14040[3] Life Cycle Assessment methodology with an ISO1401-style evaluation of aspects and impacts.

The sustainability assessment adopted the principles of the ISO14001 LCA family by adopting the following steps:

- establish the goal, scope and system
- mapping the supply chain and undertaking an inventory analysis and

[3] *ISO 14040 (2006): Environmental management – Life cycle assessment – Principles and framework, International Organisation for Standardisation (ISO), Geneve.*

- understanding potential impacts through a literature review and on-site assessment and
- evaluating the impacts using simple risk criteria ï likelihood of occurrence and severity of impact to determine the significance of the impacts.

2.2.1. Goal, scope and system

The goal, scope and system was established with the Defra project team[4] as follows:

Goal: a sustainability assessment of coir as a raw material for growing media to inform growing media manufacturers of the key impacts they need to consider and address whilst sourcing coir to enable them to make smart choices. The assessment needs to provide an evidence base that addresses the concerns of all stakeholders.

Scope: based on India and Sri Lanka because of their maturity of the coir industry and the volume of supply to the UK. The study will provide contextual information, where available, on other coir-pith producing countries.

System: starts at coconut production and will end with coir processing by the UK manufacturer ï so coir prior to formulation in bagged growing media. It is based on industry-scale and not a specific supply chain.

2.2.2. Sustainability indicators

The sustainability indicators were developed for this study through a review of indicators, protocols and standards for the following:

- the Universal Declaration of Human Rights (UDHR), standards issued by the International Labour Organisation (ILO), the International Organisation for Standardisation (ISO; ISO 14001 (Environmental Management), ISO 26000 Social Responsibility)), Social Accountability International (SAI: SA8000) and the Ethical Trading Initiative (ETI), Global Reporting Initiative
- the criteria and standards used in the Responsible Sourcing of Palm Oil, Forest Stewardship Council and Fairtrade initiatives and
- the sustainability criteria of the Sustainable Growing Media Taskforce.

As a result of this review the following sustainability indicators were adopted for this study:

- Availability of key materials at each stage of the supply chain and the factors that affected this
- Quality of key materials used at each stage of the supply chain and the factors that have an impact on this
- Economy
- Biodiversity
- Land use change
- Water, air and soil pollution
- Water consumption
- Energy consumption
- Culture
- Rural economy and

[4] The project Steering Group. Noble House. 14/2/12.

- Working conditions

Although energy sources and consumption in each of the tiers were considered in this study a full greenhouse gas emissions analysis of the supply chain was out of scope.

2.2.3. The UK's coir pith supply chain

The first step to understanding all of the potential impacts of the coir pith supply chain was to establish what the supply chain looked like for the UK. The UK supply chain for coir pith was determined through conversations with UK growing media manufacturers, importers, coconut growers, coir pith exporters and coir pith trade associations during this study – figure 5.

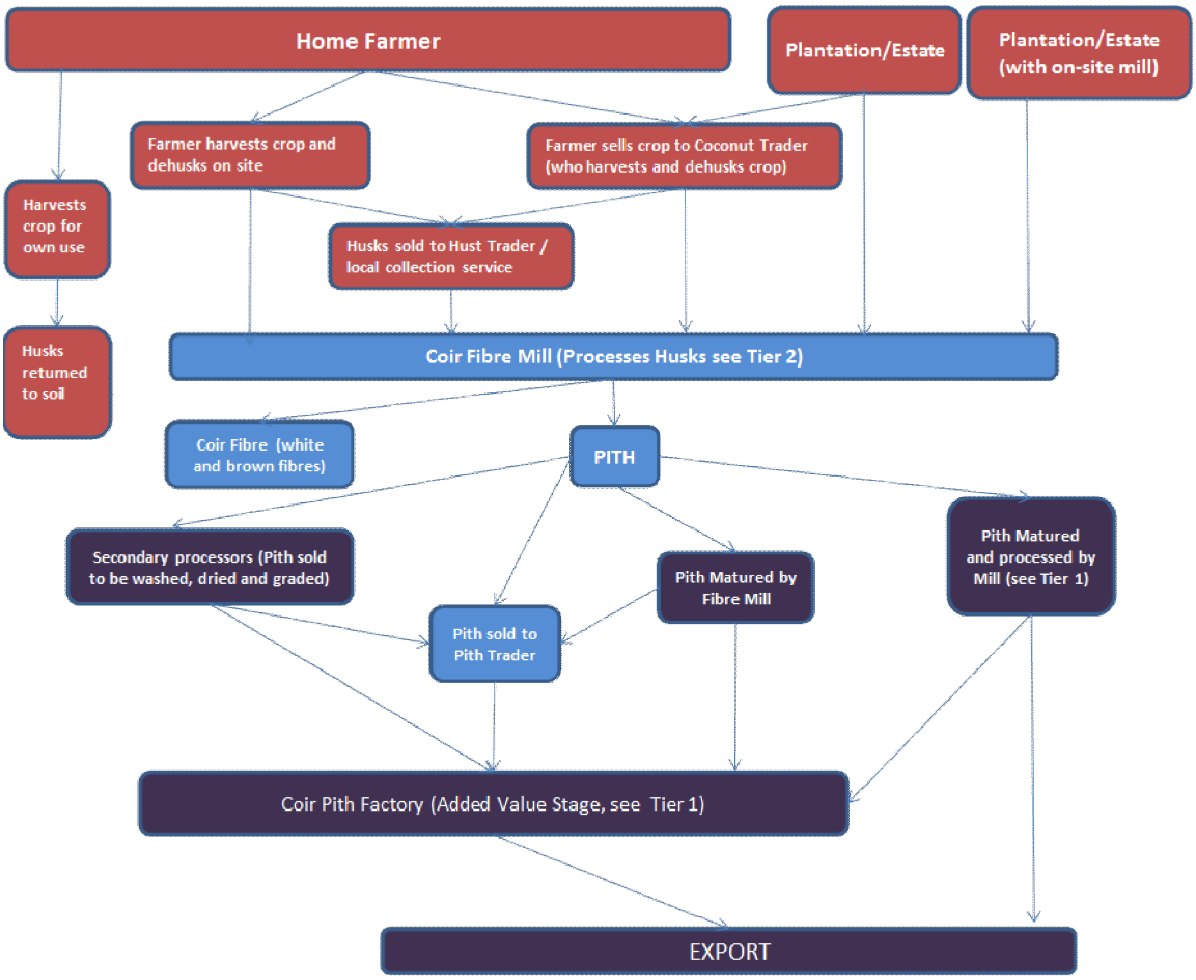

Figure 5 – UK supply chain for coir pith. Colour key: Tier 1 (purple); Tier 2 (blue); Tier 3 (red).

Through conversations with the key players in the supply chain, the coir pith supply chain can be characterised as follows:

Coconut producer: over 90% of coconut growth in India and Sri Lanka is by smallholders with an area of land up to 5 hectares.

Small holders can harvest their own crop for their domestic use, in which case the husks are generally kept on the farm and used as a fertilizer or are burnt for fuel. So coconuts from these sources rarely enter the supply chain for coir pith.

Small holders may also sell their crop to a coconut trader who brings in their own labour to harvest and de-husk the coconuts and sells the husks to a fibre mill, or a husk trader/local collector who would then sell on to the fibre mill. The small holder may also harvest and de-husk themselves and sell the husks to a husk trader or a fibre mill.

Alternatively, some plantations e.g. coconuts grown on a larger scale, have an associated fibre mill and the husks pass directly to the mills without the use of traders.

Fibre mills: the fibre mills buy in the green or brown husk and process according to the nature of the coir fibre required. The pith that is generated as a by-product of this process is then either sold directly to a pith factory or value is added to it at the fibre mill through maturing it or processing it fully before it is directly exported.

Pith processing factories: the pith factory buys the pith ï either processed to some extent or as raw pith, and adds value through maturing, washing, possibly buffering, formulating into final product and quality testing before finally exporting it.

UK growing media manufacturers and growers: some UK manufacturers and growers know which coir pith factories in India or Sri Lanka their product is sourced from. Others rely on their importer, who may source from a number of factories depending on supply, to provide the right quality pith product. In the latter case the factory source of pith may be unknown to the UK growing media manufacturer.

The UK growing media manufacturer or grower specifies the required quality standards and often tests the incoming product against these. Environmental and social criteria are not usually specified by the UK growing media manufacturers.

*Importers: m*ost UK growing media manufacturers are reliant on importers who source from a number of coir pith producers and traders in India and Sri Lanka. The choice of coir pith factories is largely based on the quality requirements of coir pith of the UK growing media manufacturers and price.

2.2.3.1. Traceability in coir pith supply chain

On-site assessments concluded that soir pith is seen in India and Sri Lanka as a waste product and so most purchases of pith are still seen as removing a problem for the fibre mill. It is also seen as a route to increasing the profitability of the coir fibre mill and the industry as a whole.

The onsite visits to pith processing factories did not reveal a requirement by the UK/ EU customer for deeper upstream traceability so in general no traceability system from plantation to finished product was being observed. The only traceability system reviewed during the literature search was an organic system that had an integrated supply chain.

Some coir pith processing factories were however found to have excellent systems that recorded every batch of coir pith into the processing yard. Some businesses had ISO 9000 certification but others had internal traceability systems that logged the name/address of the supplying fibre mill or pith trader and the status of the incoming quality control checks.

Depending on how the coir pith was processed most factories mixed all incoming batches together for further processing. Some businesses segregated each incoming batch depending on its source and further processing requirements. This material was then processed separately and sold under a standard or certification scheme.

Although no evidence was observed to show this as a common practice, with help and assistance it would be possible for basic traceability systems to be operated so that material flows could be traced back through the coir fibre mill to the main plantations or regions of supply.

This would then help the coir pith processors understand the key environmental impacts associated with each batch of incoming raw material.

2.2.4. Inventory analysis

To conduct a comprehensive sustainability assessment all of the processes, inputs and potential impacts needed to be established for the supply chain.

Conversations with all players in the supply chain in the UK, India and Sri Lanka established the key process flows in the coir pith supply chain ï figure 6.

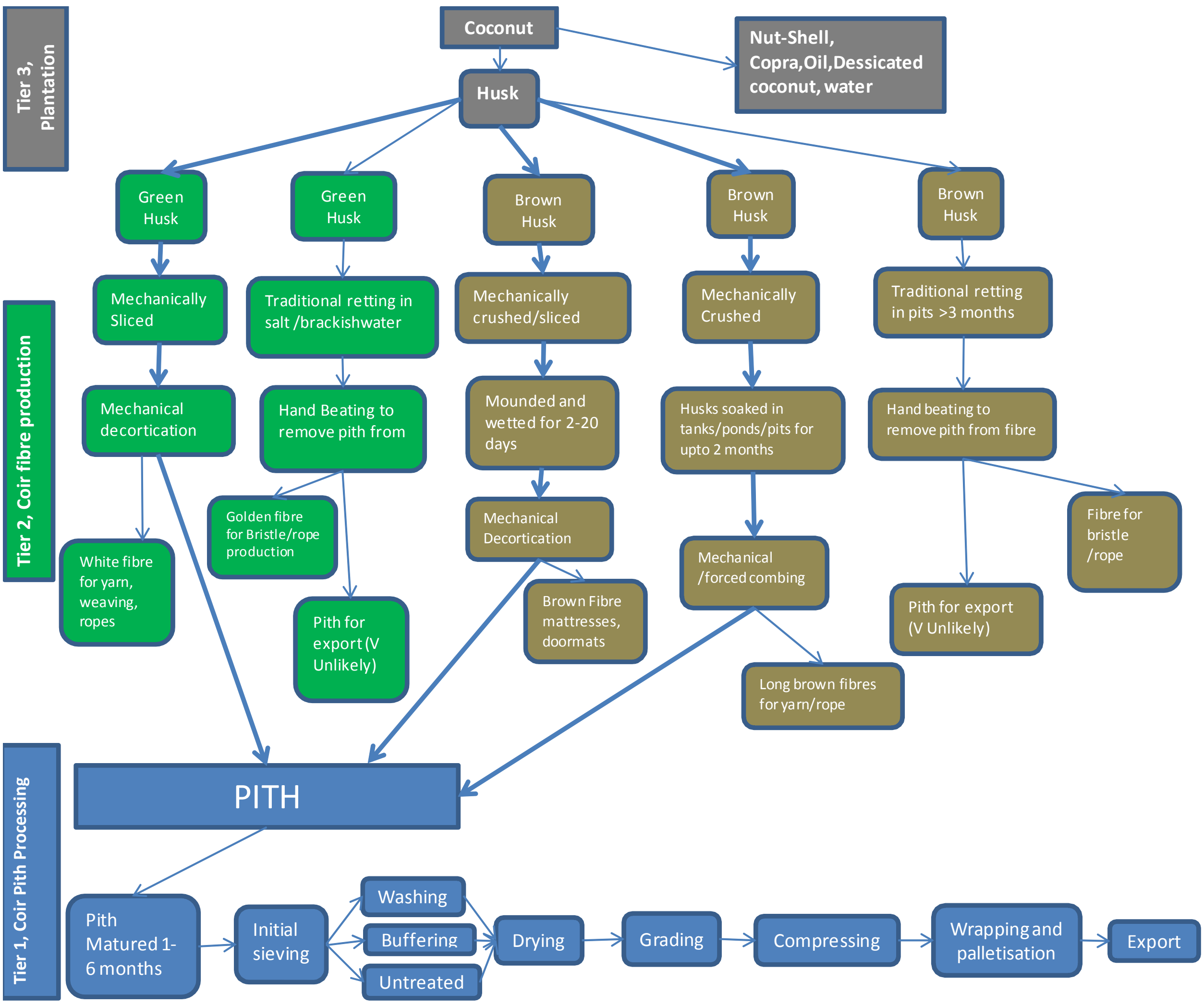

Figure 6 – processes involved in the production of coir pith.

The coir pith supply chain can be divided into three distinct tiers:

- Tier 1 is the coir pith processing
- Tier 2 is coir fibre extraction and
- Tier 3 is coconut production.

It is important to note that the supply chain for coir pith is the same as for coir fibre up until the point that coir pith is removed from the fibre mill.

From this a full inventory analysis was undertaken to understand all of the potential impacts at each tier of processing ï figure 7.

Tier	Resources	Process	Impacts
Tier 3 –coconut production	**Manual labour** Land preparation; sowing & transplanting; application of fertilizers, fungicides, herbicides; harvesting; coconut collection. **Mechanical labour** Raking; transport of coconut; weed cutting. **Inputs** Organic fertilizer; inorganic fertilizer; fungicides, herbicides & insecticides. **Regulation requirements** **Quality requirements**	Sowing Fertilization Irrigation Transplanting Fertilization Irrigation Weed/pest management Harvesting	Biodiversity loss Eutrophication Soil erosion Soil pollution Air pollution Hydrology Ethical working practices
Transport and trading	**Mechanical labour** **Traders**	Transport Sales of coconuts and husks	Greenhouse gas emissions; air pollution; congestion Fair prices to coconut producers
Tier 2 – coir fibre extraction	**Manual labour** De-husking; machine operation; sieving; soaking **Mechanical labour** Crushing; fibre extraction **Inputs** Water; fossil fuel	De-husking Soaking /retting Mechanical fibre extraction	Biodiversity loss Eutrophication Soil erosion Soil pollution Air pollution Hydrology Ethical working practices
Transport and trading	**Mechanical labour** **Traders**	Transport of coir pith Trading of coir pith	Greenhouse gas emissions; air pollution; congestion Fair prices to coir fibre producers
Tier 1 – coir pith processing	**Manual labour** Movement of coir pith around factory; sieving; grading; washing; buffering **Mechanical labour** Movement of coir pith around factory; sieving and grading; compressing; formulation into final product	Maturing Washing Buffering Drying Compressing Packaging Pallatising	Biodiversity loss Eutrophication Soil erosion Soil pollution Air pollution Hydrology Ethical working practices
Transport	**Mechanical labour**	Road haulage to port	Greenhouse gas emissions; congestion; air pollution
Shipping & onward road haulage in UK	**Mechanical labour**	Shipping Road haulage	Greenhouse gas emissions; marine pollution; air pollution; congestion.

Figure 7 – inventory analysis of all key inputs and potential impacts in the supply chain of coir pith.

2.2.5. Allocation of impacts

Clearly, coir pith shares its supply chain with other coconut-derived products and so it is important to understand the relative proportion of the observed environmental and ethical impact that can be ascribed to coir pith in Tierÿs 1 - 3. Even though a quantitative assessment was not the aim of this study it is useful to understand the relative contribution that the coir pith supply chain makes to the impacts.

There are a number of methods available for allocating impacts based on international guidance on co-product allocation including ISO14044 (ISO 2006b) and PAS2050 (BSI, 2008) using either mass allocation or co-product value. Both economic and volume values were investigated to determine an appropriate allocation for coir pith.

Conversations in India and Sri Lanka with coconut producers, fibre mill owners and coir pith processers provided the data to establish the price and mass allocation of pith for each of the tiers ï figure 8.

Tier	Price	Mass allocation for coir pith	Economic allocation for coir pith
1 ï coir pith processing	n/a	100%	100%
2 ï coir fibre extraction	Fibre mill sells pith at $220/MT and fibre at $270/MT	50%	Up to 50%
3 ï coconut production	1 husk = 1 Indian Rupee 1 nut = 9 Indian Rupees	n/a	5%

Figure 8 – volume and mass allocations to determine the relative contribution coir pith makes to the environmental and ethical impacts observed.

The volume and economic allocations were calculated where the data was available as follows:

- Tier 1 - coir pith processing: clearly as there is no further product produced in this process and so 100% of the impacts should be ascribed to coir pith whether the volume or economic allocation model is used.

- Tier 2 ï coir fibre extraction:

Volume allocation for coir fibre extraction: 33% of the weight of the husk is made up by the fibre; 66% of the weight of the husk is made up of the pith[5]. During pith processing however. 50% of the pithÿs weight is lost. The volume allocation of final material is therefore **up to 50%** for coir pith. For the purpose of this study the allocation volume is taken as 50% with the caveat that in reality it is somewhere below this figure. These approximate figures were obtained from several coir pith producers and fibre mills in India and Sri Lanka.

Economic allocation for coir fibre extraction: using the figures provided by fibre mills in India, the price they were getting for coir fibre was $270 USD/MT and for coir pith was $200 USD/MT. Using economic allocation **43%** of the impacts can be ascribed to coir pith, with 57% of the impact attributed to coir fibre, with, which roughly equates to the allocation suggested by the volume allocation.

[5] These are based on average figures. The fibre percentage can range from 33 -45% of the weight of the husk depending on the size and maturity of the husk.

For simplicity an allocation of 50% of the impacts of coir fibre extraction was ascribed to coir pith.

- Tier 3 ï coconut production

The figures were not available to undertake a volume allocation to ascribe the impacts of coconut production to coir pith.

Economic allocation for coconut production was possible using the relative value of the husk and the nut sold by coconut farmers in India[i]. In the Pollachi area of Tamil Nadu, coconuts were reaching prices of up to 10 rupees - with a nut value of 9 rupees and a husk value of 1rupee. In other areas this value was confirmed with figures in 2011 of 10,500 rupees per 1000 nuts and 1050 rupees for 1000 husks. In 2012 this figure is 7500 rupees per 1000 nuts and 750 rupees per 1000 husks. They all follow the general trend that the price ratio of nut:husk is 10:1. For the purpose of this report, it was identified that the value of the husk is approximately 10% of the whole coconut. Coir pith is 50% of this value when it is further processed and so 5% of the impacts of coconut production could be ascribed to coir pith.

Clearly the economic methodology will produce different allocations as the market prices fluctuate. For example, the price of fibre in India has dropped from $330 down to $270/tonne whereas coir pith prices have risen from $130 to approximately $200-220 in 2012.

In summary, coir pith can be allocated 100% of the impacts in coir pith processing, 50% of the impacts for coir fibre extraction and 5% of the impacts of coconut production.

2.3. Significance of impacts and identifying the sustainability hotspots

The significance of the impacts were assessed using a simple risk matrix (see section 4). This matrix is based on assessing the likelihood and severity of impact. The appropriate allocation of the impact to coir pith must also be considered in this assessment. The sustainability hotspots were identified by this process. These are the impacts that score a medium to high for likelihood and a medium to high for severity of impact.

[i] Private communication with coir pith and coir fibre producers and Government officials in India and Sri Lanka.

3. SUSTAINABILITY ANALYSIS OF THE COIR PITH SUPPLY CHAIN

This chapter outlines the findings of the sustainability analysis undertaken for each of the sustainability indicators in tiers 1-3 of the coir pith supply chain. The findings are based on literature surveys on-site visits.

3.1. Tier 1 - coir pith processing

Coir pith processing was assessed for each of the sustainability indicators identified for this study. The following results were found.

3.1.1. Availability

As a by-product and a waste product of the coir fibre industry the availability of coir pith will be determined by the strength of the coir fibre industry. Because of the requirements for water and a need for good drying conditions successful coir pith production will also be determined by regional climate and rainfall. Both India and Sri Lanka have monsoons and dry seasons that make them ideal for the production of pith. Other coconut producing countries that are developing a coir industry may well have to innovate to replicate such conditions. This may require the adoption of artificial drying conditions, for example. Further factors to consider are the availability of a labour force and the competition from other industries and a reasonable transport infrastructure to export coir pith, including access to deep sea ports for the export of material.

The burgeoning market for coir fibre along with an almost global increase in coconut production means that there is a plentiful supply of raw material. The process for producing coir fibre for coir mattresses is becoming very prominent and mechanisation to increase the productivity of this process has been increasingly adopted, particularly in India. A mattress fibre produced from coir fibre is shown in figure 9.

Figure 9 - Coir fibre mattress production.

A projection of the potential availability of coir pith, if 50% of the husks were utilised, is detailed in Figure 10, which clearly demonstrates the potential for a plentiful supply.

Country	**Production of nuts (million)**	**Potential pith production (1000 tonne)**
Indonesia	19537	2735
Philippines	12456	1743
India	12160	1702
Sri Lanka	2591	362
Thailand	1199	168
Papua New Guinea	712	100
Vietnam	680	95
Malaysia	400	56
Fiji	150	9

Figure 10: Estimates of potential coir pith production by country. This calculation assumed that the weight of the husk was 400g, with 30% of the weight attributable to the fibre and 70% to the coir dust[6]. The ratio of fibre:husk, e.g. 30:70, used to gain these figures is similar, although not identical, to the ratio 33:66 cited during the onsite visits in India and Sri Lanka.

Globally though, husks are currently underutilized and it has been estimated that only 10 ï 12 % of coconut husks are used, the remainder being used for fuel or are wasted. Even in the two largest coir producing nations, India and Sri Lanka which account for about 90% of the global coir fibre production[7], the various estimates of husk utilisation rates range from only 40 ï 60%.The Governments in both of these countries have initiatives to incentivise husk collection from fragmented, smaller coconut growers so that more husks can be utilised to benefit the rural economy.

The demand for quality coir pith from Europe, the US and Australia is rapidly growing and takes the majority of that produced by India and Sri Lanka. Pith exports from India to Gulf States are growing by 20% annually and China is also increasing its demand, although much of this is for raw, unprocessed material.

As a result of the growing markets and uses of coir pith, the price of pith is increasing and over the last year rose by 7% to between 200 - 306 USD/tonne[8] depending on whether the product is raw pith or processed into specific finished products.

From the evidence gained in India and Sri Lanka there is a plentiful supply of coir pith of the right quality for the UK horticultural market. Issues relating to supply seem to be largely connected to shorter term procurement decisions in the UK and the timing of the drying season in India and Sri Lanka.

3.1.2. Quality

One of the key challenges identified by the UK growing media community in sourcing coir pith is procuring products of the right quality for the UK horticulture market, along with the availability of higher quality material and consistency of supply. In terms of quality the key parameters are pH, electrical conductivity, bulk density, dry matter, ionic content (chloride, potassium, sodium and phosphate) and the absence of physical or microbial contaminants,

[6] Arancon, R. Proceedings of the Symposium of Natural Fibres: Coir Products (2009).
[7] *coirboard.gov.in/coirtrade.htm*
[8] Cococommunity Vol XLI No 12, 1 December, 2011.

weeds and seeds. Quality control procedures are generally undertaken by the coir pith factory, the importer and by the UK growing media manufacturer.

Generally speaking, the physical quality of coir pith is identical irrespective of the coir fibre extraction process or whether the husk that is processed is brown or green. What does differ is the chemical quality of the pith, particularly the electric conductivity. This is determined by the origin of the husks and whether it is sourced from high salt soils. More importantly for this assessment though is that husks that have been retted in saline water are generally not suited for coir pith destined for the horticultural sector unless the product is extensively washed.

The processes and methods for producing coir pith of the right quality are well known to many of the key producers in India and Sri Lanka. With the formation of Coir Pith Associations the quality issue is a key priority and to some extent self-policing of the industry is undertaken. The Sri Lankan Government has drafted coir pith standards and offers chemical and physical (not currently microbiological) testing services to coir pith exporters.

The assurance of quality also depends on the rigour of the importer and the establishment of relationships with coir pith producers to develop the products of the right quality and to ensure that robust quality control measures are in place.

A further route to assuring quality is to choose factories with appropriate certification standards for the end user. For example ISO 9001; certification of coir products for use in organic systems, for example from the National Programme for Organic Production (Regulation EEC N 2902/91, IMO, Switzerland) or RHP certification.

Although there are many processors in both countries that produce low quality pith there were many examples of good practice in the quality control for processors that are in the export market. These had good traceability, laboratories with high standards and on-site trialling facilities.

3.1.3. Economy

In both India and Sri Lanka it is clear that coir pith is making the more traditional coir fibre industry more profitable.

Looking at the value of the various materials derived from the husk ï the fibre and the pith - in relation to coconut oil and other food products it is clear that coir pith is important in the coconut value chain - figure 11. Its price is still generally below that of coir fibre but has grown remarkably considering it was a valueless waste product only 20 years or so ago.

Coconut product	Price USD/MT
Fresh coconut (Philippines)	258
Copra (India)	900
Coconut oil (India)	1800
Desiccated coconut	2300
Copra meal (Sri Lanka)	241
Coconut shell charcoal (Sri Lanka)	491
Coir fibre (Indian Geotextile)	1700
Coir fibre (Sri Lankan bristle 2 tie)	680
Coir fibre (Sri Lankan mattress fibre)	215
Coir pith	306*

Figure 11 - Prices of coconut products. Data from Cocommunity, Vol.XLII., No. 1., 1 January, 2012.
*Data from Cococommunity Vol XLI No 12, 1 December, 2011.

Coir pith will only be available if the coir fibre industry is booming and section 4.1.3. describes the coir fibre industry in India and Sri Lanka.

In both India and Sri Lanka there is a clear trend to produce and export more value added products versus raw coir fibre and pith material. Sri Lanka has until recently predominantly exported pith (and fibre) with little or no added value which is in contrast to India. Figures in 2002 suggest that fifty-one percent of Sri Lanka's coir revenues are from commodity fibre and pith exports; 97 percent of India's coir export revenues are generated by value-add products[9]. Consequently, Sri Lanka's export value per metric ton of coir material was only 38% of India's. The focus on commodity exports is changing through innovation and market orientation of key players in the Sri Lankan industry.

3.1.4. Land use change

Drying, washing and composting requires large areas of land, usually concrete or soil (Figure 12) – and an infrastructure for processing and transportation. Onsite visits identified that coir pith factories were a mix of new and old build on land previously used for agriculture, brown field sites and industrial zones. The land use change is likely to be mostly low impact with no evidence to suggest land use change from a natural environment for coir pith processing.

[9] A competitiveness strategy for Sri Lanka's coir industry. 2002. US Agency for International Development Mission to Sri Lanka. Contract No. PCE-1-801-98-000-16-00.

Figure 12 – Drying area for coir pith

3.1.5. Water, soil and air pollution

After the coir fibre is extracted from the husk the pith can be collected and processed to enter the supply chain for the production of horticultural grade material.

The process for the production of coir pith for horticultural grade material follows a number of steps depending on the requirement of the end user and customer.

It is firstly matured for up to 6 months. This serves to reduce the salt content, to change the pH from acidic to neutral, to reduce the content of tannins and phenols in the pith and to achieve a more favourable carbon to nitrogen ratio.

The pith is then initially sieved to remove physical contaminants and remaining coir fibre.

This is followed by washing with water to further reduce the salt content. An additional stage could be buffering at this point if required by the end user. The pith can be buffered using the same process as washing, except that calcium nitrate is mixed with the water, followed by a further washing step. Buffering displaces sodium and balances the naturally occurring potassium. It prevents unwanted lock out of calcium and magnesium and avoids sodium toxicity issues.

The washed (and buffered) pith is then dried and processed into the format required by the customer ï bagged, graded or compressed ï before it is packaged for export to the UK.

In terms of impacts, coir pith processing requires extensive washing with water to reduce the salt concentration. The run-off from these processes will contain high levels of sodium and potassium ï figure13. Waste water has also been shown to contain 27.8% cellulose, 28.5% lignin and 8.12% soluble tanning-like phenolic compounds[10] and microbial contamination as well as other physical contaminants such as sand, grit and stones. Kasthuri *et al*[11] report that biochemical oxygen demand (BOD), chemical oxygen demand (COD), nitrates, nitrites,

[10] Vinodhini, S., Padmadevi, S.N and Srinivasan, P. 2006. Biodegradation of lignocellulosic coir pith by using fungal forms, Asian J. Microbiol .Biotech. Env.sci, 8(3):499-502.

[11] Kasthuri, J., Cholarajam, A., Vijayakumar, R. And Muthukumaran, P. (2011). Physico-chemical and microbial analysis of coir fibre effluent. Asian J. Res. Pharm. Sci. 2011; Vol. 1: Issue 2, Pg 44-46.

ammonia, calcium and magnesium were recorded in high amounts, as were bacteria, fungi and algae in the wastewater from the coir industry.

Figure 13 – An example of coir pith washing where the run-off is allowed to contaminate underlying soil. Better practices were seen where the washing process occurred on concrete surfaces, where the run-off was collected and where the run-off was treated.

Clearly, if the coir pith is buffered with calcium nitrate this process will lead to further environmental issues concerning effluent from coir pith processing. Calcium nitrate has the potential to cause eutrophication if released directly to water or land.

It is possible to significantly reduce the environmental risks concerned with effluent from coir pith processing by collecting and treating the effluent. In one case during the onsite visits this was observed and the treated wastewater was then used to irrigate agricultural crops. However, during the on-site visits the majority of coir pith processors do not treat the effluent from the washing (and buffering) process. Some do dispose of their untreated wastewater, including wastewater from the buffering process, directly on to agricultural crops.

The pollution of water, soil and air is covered by a number of laws and regulations in India and Sri Lanka as detailed in Annex 1. The level of compliance to these laws and regulations in the larger coir pith processors will be governed by Government Departments in both countries.

3.1.6. Biodiversity

Biodiversity is likely to be impacted if the untreated effluent from the washing and buffering steps enters surface or ground waters. Wastewater from the buffering process will contain high levels of calcium nitrate and will likely cause eutrophication if released in to water bodies with a resultant impact on biodiversity.

Other wastes will also be generated ï such as plastics and un-used raw materials ï which also need to be disposed of responsibly.

3.1.7. Water consumption

The washing and buffering processes for coir pith requires large volumes of water. On-site studies suggest that up to 300 litres are required to wash 1 cubic metre of coir pith in controlled (tanked) environments. Other sources suggest that up to 600 litres are required[12], although this will change depending on the season, the rainfall patterns and volumes in different coir pith processing regions and with the efficiency of the washing process.

Water conservation measures adopted by coir pith processors were only observed in one case during the processors washing process. In this case over 60% of the water was conserved.

3.1.7.1. Water availability in India

India is endowed with large freshwater reserves but increased population and the overexploitation of surface and groundwater, along with changing levels and patterns of rainfall has resulted in water scarcity in some regions. The growth in the Indian economy is driving increased water use across all sectors. Waste water is a significant issue and the absence of proper measures for the treatment and management of water means that the existing freshwater reserves are becoming increasingly polluted[13]. Increased urbanisation is driving an increase in the *per capita* consumption in towns and cities, as well as a change in consumption patterns and demand for water intense crops and industrial products. One 2025 scenario predicts that globally, India and China will have to address the largest water stress issues[14].

India's usage of water amounts to 501 billion cubic metres (BCM)[15]. Irrigation is responsible for 83% of the use, followed by domestic consumption (5%), industrial and energy consumption (5% each). The key water consuming crops are rice, wheat and sugarcane.

In India the most significant coconut growing areas are Kerala (48.79%), Karnatka (18.9%), Tamil Nadu (17.7%) and Andhra Pradesh (5.5%) which together account for 91% of India's coconut growth. The coir fibre production and coir pith processing industries are mainly focussed in Tamil Nadu.

Falkenmark's Water Stress Index[16], based on the minimum *per capita* water requirement for basic household needs to maintain good health the areas of India that are water stressed (freshwater availability is less than 1700 cubic metres *per capita* per year) and water scarce (freshwater availability is less than 1000 cubic metres *per capita* per year) can be used to identify the areas of most concern.

Using this approach the state of Tamil Nadu, with its average rainfall of 950 mm per year is generally water scarce. Some areas in the southern tip have less than 500 cubic meters per

[12] Personal communication, Tom de Vesci.
[13] www.grailresearch.com/pdf/.../Water-The_India_Story.pdf
[14] Global water initiative. 2006. GEF International Water Conference. The Coca Cola company.
[15] Government of India, 11th 5 year plan for water management and irrigation.
[16] Falkenmark. "The massive water scarcity threatening Africa-why isn't it being addressed." *Ambio* 18, No.2. 112 - 118. 2 (1989): 112-118.

capita per year. The state has 17 major river basins and most are water stressed[17]. Declining water tables have dried up more than 95% of the wells[18], leading to the loss of arable land and an increased dependence on rainfall. The extraction from the main river, the Kaveri, means that groundwater levels for Tamil Nadu are likely to reduce by a further 50%[19].

To control water use and quality Tamil Nadu has a Groundwater Bill, Procurement/Right to Transparency and a Farmer's Management and Irrigation Systems Act. Tamil Nadu also has a planning framework for water resource management and a State Water Policy.

The other coconut, fibre and pith processing regions in India fare slightly better in terms of rainfall. Kerala has an average rainfall of 3000 mm per year. The majority of this results from two monsoons – the North East Monsoon from November to February and the South West Monsoon running from June to September. Despite this Kerala has the lowest *per capita* rainwater availability in India due to issues of pollution and water mismanagement. This is more of a concern for the fibre value-add industry. Karnataka has an average annual rainfall of 1248 mm; and Andhra Pradesh has an average of 1000m per year.

The Government of India's Ministry of Water Resources ended a public consultation in March 2012 on its new national water policy[20]. The aims of the policy are to launch a number of initiatives to prioritise water for human and ecosystem needs, improve water infrastructure and efficiency across all sectors, incentivise the re-use and recycling of water and improve waste treatment. The likely impact of this on the coir pith supply chain is that water consumption from their private boreholes will be regulated and will require some sort of payment, rather than be free and unregulated as it currently is as revealed during the onsite visits.

3.1.7.2. Water availability: Sri Lanka

Several studies present Sri Lanka as having no to moderate water scarcity issues at the national level, although there are spatial and temporal variations in availability and demand to consider in various districts[21].

There are two zones in Sri Lanka classified by their annual rainfall – the wet zone and the dry zone. The wet zone receives about 2350 mm rainfall per year, whilst the dry zone receives an average of 1450 mm per year. More than 90% of the current withdrawal of water in Sri Lanka occurs in the dry zone. The majority of this, 96%, was for agriculture, 86% of which was for rice production. The remaining 10% was withdrawal for irrigation of all other crops.

Some coir pith processing in Sri Lanka does occur in the dry zone. Water conservation measures are therefore prudent for all coir pith processors in both countries.

---

[17] Palanisami, K et al. 2011. Performance of agriculture in the river basins of Tamil Nadu, Centre for Agriculture and Rural Development Studies, Tamil Nadu Agricultural University, Coimbatore.
[18] IDSA Taskforce. 2010. Water secretariat for India. The external dynamics. ISBN 81 86019 839.
[19] India's water future to 2050. International Water Management Institute
[20] wrmin.nic.in/index1.asp?linkid=201&langid=1
[21] Amarasinghe, U., Mutuwatt, L. and Sakthivadird, R. 1999. Research Report of the Institute of Water Managment. ISBN 92-9090-383X.

3.1.8. Energy consumption

The processing of coir pith requires the operation of sieving machines and compressors, generally fuelled by energy from the grid. In India this was a mixture of coal fired power stations although a percentage of this was also supplied by wind power in Tamil Nadu. The rising costs of fossil fuels in India and Sri Lanka generally mean that the coir pith is collected from coir fibre mills within a 20km or so radius of the coir pith processing unit. Clearly the larger the producer the larger radius needs to be to obtain the required volumes of pith. In the study of a specific supply chain it would be possible to identify these figures.

The drying process is generally through a natural process using sunlight during the dry seasons. Practices were observed during onsite visits in both countries that permit drying under wet conditions.

3.1.9. Cultural

Coir pith processing is a recent development utilising the waste from the traditional industry of coir fibre extraction. It economically supports the coir fibre industry in India and Sri Lanka. The coconut is very important to the cultures of India and Sri Lanka (see section 3.3.9.).

3.1.10. Rural economy

The demand for coir pith makes the traditional fibre industry more profitable and is very important to the rural economy.

3.1.11. Working conditions

The labour laws for India and Sri Lanka are extensive and are presented in Annex 1.

If implemented appropriately the laws of India and Sri Lanka will protect the workforce from unethical practices. Their implementation, however, is dependent on whether the factories in question are in the formal or informal employment sectors of India and Sri Lanka

The informal sector refers to the part of the economy that is untaxed, not monitored in any form by the government and not included in the Gross National Product calculations. The informal sector is prevalent in all developing countries and falls outside of the modern industrial sector. It comprises the self-employed workers, home-workers and both wage earners and non wage earners. The largest population in this sector is female and so raises significant concerns over gender effects. The size of the informal sector in India and Sri Lanka has been estimated as 22.4% and 43.9% respectively of Gross Domestic Product[22].

In terms of the working practices and conditions in the coir pith processing sector there was certainly evidence of good practice, generally where coir pith producers are directly linked to European growing media manufacturers or importers. In these cases the

[22] Schneider, F., Buehn, A. And Montenegro, C. 2011. 'Shadow economies all over the world'. World Bank Research Working Paper 5356.

productivity, quality, environmental and social issues are also generally better addressed.

The key issues relating to working conditions concerned the levels of coir dust found in the pith processing factories and their environs, even in the formal, regulated sector. Every factory visited had an issue with dusty working conditions, some were considered extreme whilst others undertook good manufacturing practice by keeping floors and machinery free from coir dust which had a big impact on the air quality. Many factories provided dusk masks for employees ï figure 14. Although this helped, the use of personal protective equipment (PPE) did not remove the issue of excess dust in these sites. Wearing of PPE was also very uncomfortable in conditions of very high temperatures and humidity. Some factories had plans to adopt new practices and innovations to remove more dust from the work area in the future.

Figure 14 – The use of personal protective equipment in coir pith processing facilities.

A few coir pith processors had undertaken a formal ethical audit either on a voluntarily basis or on behalf of their customers. Unfortunately this was not the norm and so independent scrutiny of wages, working hours etc had not taken place. Most of the facilities visited operated at least a 6-day week with multiple shifts which presents a higher risk for potential labour issues and a need for greater transparency of their ethical management. Both India and Sri Lanka have adequate labour legislation for the formal, industrial sector. Where coir pith processors fall in to the formal sector the risks are likely to be much lower. Onsite visits established that government authorities do regularly inspect sites to assure compliance.

The greatest risk is seen to be with the smaller coir pith processing units that fall in to the informal sectors and so would not be inspected by the Government to identify and rectify bad ethical practices

3.2. Tier 2 - coir fibre production

Coir fibre production was assessed against each of the sustainability indicators identified for this study. The following results were found.

3.2.1. Availability

The availability of coir fibre will be dependent on large scale coconut production, availability of a labour force and infrastructure to collect and process coconut husks in to fibre.

Currently the global annual production of coir fibre is about 350,000 metric tonnes (MT). The top producers are India and Sri Lanka which together account for about 90% of global coir fibre production[23]. Other countries looking to expand their coir fibre industry include Vietnam, Thailand, Philippines and Indonesia.

The traditional uses of coir fibre include rope and twine, brooms and brushes, doormats, and rugs. A boom in the production of coir fibre has resulted from the following key markets and products:

- a huge increase in demand of coir fibre from China which is the major buyer of coir fibre products in the world market, with a consumption only second to India. Since 1990, India has roughly doubled production to satisfy domestic consumption. Although this includes all coir fibre products the most significant product is mattress fibre where there has been a huge boom for sleeping comfort in China and India.

- an expanding market for coir-based erosion control products, geotextiles, particularly in Europe, Asia and the US as erosion control blankets, nets for slope protection and keffed coir for river/canal bank support.

- coir fibre use in the car industry of Europe and the USA where it is used to reinforce products for automotive interiors to reduce cost and weight; rubberized coir is also used in car seats

- the construction sector is using coir-based composites for thermal insulation in home construction; wall panels from blast furnace slag cement is being mixed with coir in Brazil and ecocoboards are being increasingly produced for mass housing developments. Coconut fibres are also used in road construction when mixed with asphalt and in unpaved rural roads

The Governmentҫs of India and Sri Lanka have recognised the economic importance of husk utilisation and both are sponsoring initiatives to increase husk collection and utilisation rates for coir fibre (and pith) production. Indiaҫs Government is also protecting the availability of husks by banning their use in an emerging market of biofuels.

In summary, the demand for coir fibre is growing at a rapid rate due to new markets demanding new products as more uses of coir fibre are found in the modern world and there is an increasing demand for more natural and sustainable products.

3.2.2. Quality

Coir fibre can be derived from the green or the brown husk using a number of processes depending on the quality of the fibre required.

---

[23] *coirboard.gov.in/coirtrade.htm*

3.2.2.1. Green husk processing

There are two different processes for extracting coir fibre from green husk.

The first is for the production of white fibre used to make yarns for weaving and rope. In this process the green husks are sliced by machine into smaller pieces. These pieces are then fed into a decortication machine to separate the fibre from the pith ï figure 15.

Figure 15 ï fresh, green husks ready for fibre production

The second is the traditional process for producing golden fibre and bristle fibre for brushes. Here the green husks are soaked in salt or brackish water for up to nine months. After this time the fibre is extracted from the husk by hand beating ï figure 16. Lower levels of coir pith are recoverable from this process as much of it separates from the fibre during the soaking process. In this process the pith is not generally utilised further for horticultural grade products.

Figure 16 - Traditional production of coir fibre. A: Coconut husks soaked in water on the edge of a lagoon. B: Retted husks are beaten and combed to produce golden fibre and bristle fibre.

3.2.2.2. Brown husk processing

There are three different processes for extracting coir fibre from brown husks.

The first process is for the production of fibre for mattresses and geotextiles. A machine is used to mechanically crush or slice the husk. During this stage an initial amount of pith is recovered. The crushed or sliced husks are then wetted for two days or so before they are placed in a decorticating machine ï figure 17. The majority of pith is recovered at this stage as the fibre is separated from the pith.

Figure 17 – Mechanised production of coir fibre.

The second process is to produce long brown fibres. The husks are crushed and then soaked in tanks or ponds for up to 2 months. They are then removed from the tanks or ponds and combed mechanically to produce the fibre and the pith is separated from the fibre during this process ï figure 18.

Figure 18 – Husks soaking in a tank and then fed by hand into a machine which is located in the shack in the first photograph, to remove the fibre.

The third process is the traditional production of bristle fibre and rope. The brown husk is soaked in water for up to nine months. The fibre is extracted by hand beating. The pith is not recovered in high concentrations.

3.2.3. Economy

The coir fibre industry is of great economic importance to the major coconut growing areas of India and Sri Lanka.

Traditionally, Sri Lanka had been the world's largest exporter of the various coir fibre grades whilst India was the largest exporter of value added products, such as yarn, mats and rugs. Sri Lanka's coir exports accounts for 49% of the global market, followed by India at 23%. An increasing volume of India's production is consumed domestically. The remainder of coir products on the export market comes from Indonesia, Philippines and Thailand[24].

Of Sri Lanka's coir export 90% is raw fibre to other countries who are financially benefitting from further value addition. In 2011,Sri Lanka earned $51 million in export revenue from coir products and $39.7 m from exporting raw coir. The Ministry of Industry and Commerce is taking steps to protect its industry by promoting initiatives to export value added coir products for greater economic gain. It is investing in the development of machinery and promoting the further utilisation of the husk.

In terms of export revenue, Europe and the US account for 72% of India's coir product exports – Europe is currently the largest. There are also growing demands from Russia, Latin America and Africa.

China's import demand grew at a rate of 25.5% during 2004-2010[25]. China is the engine for growth in the coir fibre market, leading to increased production by the Philippines and Indonesia. China imports 97% of the total raw fibre export from Indonesia and about 90.3% of the total raw fibre exported from India. China is also a major buyer of Sri Lankan coir fibre, importing 71% of Sri Lanka's total export market of mattress fibre alone.

[24] Coconut Statistics Yearbook. 2009. Asian Pacific Coconut Community.
[25] Cocommunity, Vol. XLI No. 12, 1 December 2011.

3.2.4. Land use change

The traditional coir fibre mills are located within the coconut plantation or very nearby. Larger scale fibre mills are more likely to be found in agricultural, urban or industrial zones.

3.2.5. Water, soil and air pollution

There are a number of significant impacts relating to coir fibre processing. Although the occurrence of these are entirely dependent on the process adopted for the extraction of the coir fibre. Details of the processes available to process the husk for fibre production can be found in 3.2.2. This describes green and brown husk processing, the different machines available and the traditional retting process.

3.2.5.1. Retting

One of the key environmental and social concerns with coir fibre production is the utilisation of a process known as retting.

Retting is a process that soaks husks in water for up to nine months to aid the removal of the fibre prior to extraction by hand beating.

The traditional process for coir fibre production used this process. The pectinolytic activity of microbes, especially bacteria, fungi and yeasts, degrade the coconut fibres making them easier to remove from the husk and subsequently process. Retting generally takes place in rivers, lakes and seawater lagoons.

The pectinolytic activity releases large amounts of organic matter to the environment leading to turbidity, reduced dissolved oxygen, depletion of nitrate and sulphate, production of hydrogen sulphide and methane, carbon dioxide and other polluting chemical such as pectin, pentosan, tannins, and polyphenols ï figure 19. Generally, the water phosphate and nitrate concentrations increase whilst dissolved oxygen and the diversity of plankton reduces. This has had a large impact on the quality of water and the land and air quality of the environs. The impacts on biodiversity, habitat and ecosystems are well documented.

Figure 19 – Visible pollution caused by retting. Both of the retting zones above are in areas with a designated conservation status.

The retting pools are highly contaminated with microbial agents, further exacerbated when the freshwater pools are used by livestock. This has a potential impact on the quality of the product which, for UK markets, needs to be free from microbial contamination and safe for use.

Retting zones have revealed extensive damage to the environment, foul smells and health impacts on the local communities, rise in water temperatures, frothing liquid and white film formation and extensive damage to aquatic species of the backwaters. The health and pollution aspects of retting have been well documented along with the release of the greenhouse gas, methane[26] [27] [28] [29] [30] [31] [32] [33] [34] [35] [36] [37] [38] [39] [40].

[26] Remani, K.N., Nirmala, E., and Nair, S.R. 1989. Pollution due to coir retting and its effect on estuarine flora and fauna. *Intern. J. Environmental Studies* 32, 285-295.

[27] . Umayorubbhagan, Albert, G.M.I., Ray, C.I.S., 1995. Physicochemical analysis of the water of Pottakulam lake at Thengapttanm in Kanyakumati district (Tamil Nadu). *Asian J. Chem Rev*. 6, 7-12.

[28] Nandan, S.B. and Abdul Azis, P.K., 1995. Benthic polychaetes in anoxic sulfide biomes of the retting zones in the Kadinamkulam Kayal. *Int. J. Environm. Stud*. 47, 257-267.

[29] Abbasi, S.A. and Nipaney, P.C., 1993. Environmental impact of retting of coconut husk and directions for the development of alternative retting technology. *Pollut. Res*. 12, 117-118.

[30] Abbasi, S. A & Remani, K. N. 1985. Environmental. pollution due to retting of coconut husk and preliminary studies on closed system retting. *Proc. Workshop on Coir Research, Coir Board. Alapuzha,* pp. 121-131.

[31] Abdul Aziz, P. K. 1974. Preliminary observations on the ecology of the coconut retting grounds in the back water systems of Kerala. *Proc. Envirqnmental Pollution in Kerala.*

[32] Abdul Aziz, P. K. & Balakrishnan Nair, N. 1982. Ecology of the crustacean plankton of the retting zone with special reference to sulphide pollution in a backwater system of Kerala. *Mahasagar:. Bull. Natn./nst. Oceanogr.* 15: 175-182.

[33] Abdul Aziz, p .K & Balakrishnan Nail, N. 1986. Ecology of the coconut husk retting grounds in Kerala. *Proc. Symp. Coastal Aquaculture. Trivandrum, Kerala,* pp. 1115-1130.

A recent study in Tamil Nadu[41] analysed the physiochemical parameters of water in a coconut husk retting area including pH, EC, turbidity, total dissolved solids, alkalinity, total hardness, dissolved oxygen, chemical oxygen demand, hydrogen sulphide and calcium, magnesium, ferric, manganese, nitrate, nitrate, sulphate and phosphate ions. Hydrogen sulphide is a strong indicator of high organic pollution. Nearly all samples exceeded the permissible limit set by the World Health Organisation and the Central Public Health and Environmental Engineering Organisation (CHPEEO) Water Quality Guidelines.

Clearly traditional retting leads to significant pollution of water, air and soil and concomitant impacts on habitat and ecosystems.

As observed predominantly in India modern coir fibre production methods do however significantly reduce the environmental impacts of coir fibre production.

With the mechanical methods for fibre production, as outlined in 2.4.3., the nine month retting process is becoming obsolete. This is very much the case for India and the mechanisation rate is also increasing in Sri Lanka.

Green husks can be dry milled without retting and only need to be dampened with water but brown husks are sliced and soaked for 2 ï 20 days before being de-fibred. Brown husks are used to produce mattress fibre. The key issue here for the pollution of soil and water is the run-off created by the need to soak the sliced/crushed husks prior to defibreing. Large

---

[34] Bijoy Nandan, S., Abdul Aziz, P .K. & Natarajan, P. 1989. Water quality and faunal depletion in the retting zones of the backwaters ofKerala. *Proc. First Kerala Science Congress. Cochin, Stale Committee on Science Technology and Environment*. Government of Kerala. Trivandntm, pp.167-175.

[35] CWRDM 1989. *Assessment of pollution due to retting of coconut husk and development of alternative retting technology.* Final Project Report submitted to State Committee on Science, Technology and Environment, Govt, of Kerala, Trivandrum, 30 pp.

[36] Remani. K. N., Venugopal.. P., Saraladevi, K. & Unnithan, R. V. 198 I. Sediments of retting yards. *Indian J. Mar. Sci.* 10:41-44.

[37] Jeyarajd, D. Selvaraj, R.D., Jones, S and Chothra G. 2001. Coconut husk retting effluent and fish species diversity in river Pankilal, Kanyakumair district. C. Thampi. Indian Journal of Fish 48(3): 249 – 254. July – September, 2001.

[38] Ambika Devi, M.1993. Coconut husk retting is one of the most important sources of pollution in the Cochin backwaters (Ecological studies on coconut husk retting area in the Cochin back water and its relation to fish seed availability). *CMFRIspl. publ.,* 54:14-20.

[39] Lazarus, S., Prema,P and Sivakumar, V. 1998. Fish mortality due to retting effluent in the summer in the Pannaiyoor backwaters. The impact of retting effluent on the fish fauna of Rajakkamangalam estuary- A case study. *Proc.Sym.Environ.Pollut,Alwarkurichi.*

[40] Jayanthi, A., Jeney, C. and Suhiji. S. 2009. A comparative analysis of coir and sugar mill effluent. *Asian Journal of Water, Environment and Pollution*. Vol. 7. No 2. P 73 – 76.

[41] Mary Helen, P.A., Jayasree, S., Johnson, J., Belsha, J., and Chittarasu, I.H. (2011). Seasonal variations in the physio-chemical properties of water in coconut husk retting in Tamil Nadu. *International Journal of Environmental Sciences*. Volume 1, No 6.

mounds of sliced husks are formed and then soaked with water usually using a hosepipe. Some factories use concrete floors, where the run-off can be collected and potentially treated, although little evidence was seen for the treatment of the effluent. Other factories put the sliced husks directly on to the soil for the soaking process. Run-off therefore enters the groundwater. At this stage the run-off is likely to contain high salt which may contaminate ground water.

Other processes soak the husks in water tanks for 2 months which is still dominant in Sri Lanka, although was less frequently observed in India.

Despite there being an opportunity to treat the effluent of these tanks before releasing to the environment there was little evidence that this was a common practice in either India or Sri Lanka. One pith factory in Sri Lanka stated that a number of their suppliers did regularly flush the soaking tanks with clean water to reduce the build up of contamination but no direct evidence of this was obtained to confirm this practice or the treatment of the effluent.

In summary, the traditional nine month retting process is still practised in India and Sri Lanka by the traditional, home-farm style coir fibre producers. The amount of pith that is recoverable from such processes are much lower than that found in other coir fibre producing processes. Much of it sediments out during the retting process and is itself the major cause of pollution. The quality of the pith further limits its use in the coir pith supply chain. Coir pith from this process is irreversibly expanded and has a high salt content if soaked in seawater or brackish water. The likelihood of coir pith from this process entering the UK supply chain is assessed as being very low.

The two month retting process is more prevalent in the coir fibre production in Sri Lanka, but was rarely observed in India with the greater uptake of dry processing and mechanisation. Although few effluent controls were observed to be in place in Sri Lanka it would be relatively straightforward to control via the use of tanks, rather than open waterways/pits, and effluent treatment.

The process with the lowest environmental impact would be the mechanised process as it avoids retting all together.

3.2.5.2. Dust

Coir fibre production does create dust and potentially reduce the air quality in the environs of the larger coir fibre production units.

3.2.6. Biodiversity

Clearly traditional retting will have a large impact on biodiversity and ecosystems. If husks are soaked for two months and the water is not treated prior to disposal then this also will impact on biodiversity. The use of the untreated effluent from the 2 months retting to irrigate coconut plantations or other crops was observed. There were anecdotal reports that there were no adverse impacts on the surrounding plantations through this practice, although no scientific studies had been undertaken to support or dispute this claim.

3.2.7. Water consumption

Traditional retting occurs in rivers, lakes and the sea. This presents a significant challenge to water quality and the availability for consumption by other users.

The main process that consumes water in coir fibre processing is the mechanised process for producing mattress fibre. After the husks are sliced or crushed, they are soaked for 2 - 20 days to facilitate the removal of the coir fibre. The water used is from the private borehole or well and its use is unmetered and generally unaccounted for.

3.2.8. Energy consumption

The mechanical extraction of coir fibre requires the use of fossil fuel. The machines can run up to 24 hours a day. Although it would be possible to calculate the amount of energy used for coir fibre processing a full greenhouse gas assessment of the supply chain was outside of the scope of this study.

There are some private initiatives that are exploring the use of biofuels to power the coir fibre factory, which will significantly reduce the burden of power consumption on the grid and also assure continued operations throughout the ever present power cuts in India and Sri Lanka.

3.2.9. Cultural

The coir fibre industry in India and Sri Lanka is a traditional industry with long established weaving and rope-making skills and a significant part of the cultural heritage of many regions.

3.2.10. Rural economy

The global trade volume of coir fibre value added products ï yarn, mats and pith ï stood at $140 m a year with India and Sri Lanka accounting for about $70 and $60 million respectively.

The coir fibre industry is a highly significant economic factor for supporting the rural economy in the coconut growing regions of India and Sri Lanka. The coir industry in India, for example employs 400,000 people (550,000 including part time workers).

The labour force in the coir fibre industry is largely dominated by women providing supplementary income for the family.

The current economics of coir production is very dependent on cheap and abundant manual labour. The downside to mechanisation to increase productivity will put people out of work, particularly in the traditional handloom sector. The key is to find a way of increasing productivity by increasing mechanisation that also offers more opportunities for employment, better wages, improved conditions of working and a better quality of life.

Better organisation of the coir industry, through cooperatives in India and Sri Lanka, has the potential to aggregate the produce from smaller-scale farmers into a larger pool of raw material for the upstream players in the supply chain and bringing in the benefits of a greater economy of scale.

In Sri Lanka the Ministry of Coconut Development has a plan to organise smallholders as Community Based Organisations (CBO) to generate small/medium scale industries to increase employment opportunities and alleviate poverty. Oxfam, in collaboration with the government and industry has successfully established a cooperative coir fibre production model. The project[42] , part of Oxfam's strategy for 'Poor Women's Economic Leadership' has empowered women, invested in equipment to sustain their coir fibre production, taught the workers key business skills and built strong private and public partnerships with producer organisations. This project directly supported 1700 female coir workers and indirectly impacted 4500 family members.

3.2.11. Working conditions

This is probably one area which suffers most from ethical issues. Technically speaking a coir mill (operating machinery and employing people) should be classed as part of the formal sector and therefore governed by all the applicable labour and health and safety laws of that country. The risk of coir fibre mill being part of the informal work sector is considered to be high and needs to be appropriately investigated for each supply chain.

In practice the standards observed during the on-site visits varied tremendously and varied between India and Sri Lanka.

The differences between the countries can be mostly attributed to the larger uptake of mechanisation for the production of mattress fibre by India which removes some of the more significant health and safety issues such as longer term retting pools and the use of needle drums for fibre extraction – figure 20.

Figure 20 – Needle drum used for fibre extraction. Most found without guards to protect the workforce who hand-feed these machines with retted coconut husks.

The ILO and partners has developed guidelines for 100 good working practices for coir mills[43]. This was based on an extensive study into the working practices of coir mills in Sri

[42] www.oxfam.org.uk/.../Sri%20Lanka%20Womens/New%204839_sri...

[43] "www.entergrowth.com/download.php?type=projects&id=68 100 good "working practices - guidelines for coir fibre mills.

Lanka in 2006. It has well documented standards that should be observed to address the ñunsatisfactory workplace practicesò found within the industry. The study noted that for all mills visited during the assessment, some of these practices were being carried out but all mills had many ethical issues still to manage. It also noted that no child labour was observed in any of the mills visited. Equally no forced labour was observed but it was mentioned by NGOõs visited during the on-site assessments but this could be an issue in small scale rural mills that are situated within the grounds of larger estates/plantations.

There is a high risk of serious health and safety issues being found in coir fibre mills, particularly in Sri Lanka.

Many of the more traditional mills do not operate safe perimeters/fencing allowing free access to the site and hazardous equipment.

Some mills visited in India who process in excess of 30-50,000 husks a day operated modern machinery, this was generally kept in good and safe working order where safety cut out switches were found to be present and in working order. Mills that relied upon more traditional techniques to recover fibre were found to be at most risk of unsafe equipment. Traditional machinery was found to have few safety features and loss of fingers is well documented.

Some mills visited who have longer term trading relationships with coir pith factories were aware of their customerõs quality standards but none had any documented ethical management practices or had undergone any type of ethical assessment. This in part is due to the nature of the industry, the fragmented supply chain, the size and rural location of the mill and the lack of official scrutiny. None of the mills visited had been requested to undertake an ethical audit by their coir pith customers.

Some mills visited that were part of a more integrated supply chain e.g. all processes from the husk to a finished product ready for export generally demonstrated higher levels of ethical practices. This was also more noticeable where the mill was part of the export company and practices were being cascaded down through the various parts of the business.

3.3. Tier 3 - coconut production

This is the beginning of the UK coir pith supply chain

3.3.1. Availability

There are almost one hundred coconut producing countries, with a collective growing area of 10 million hectares (ha). The highest producing countries are Indonesia, Philippines, India, Brazil and Sri Lanka ï figure 21.

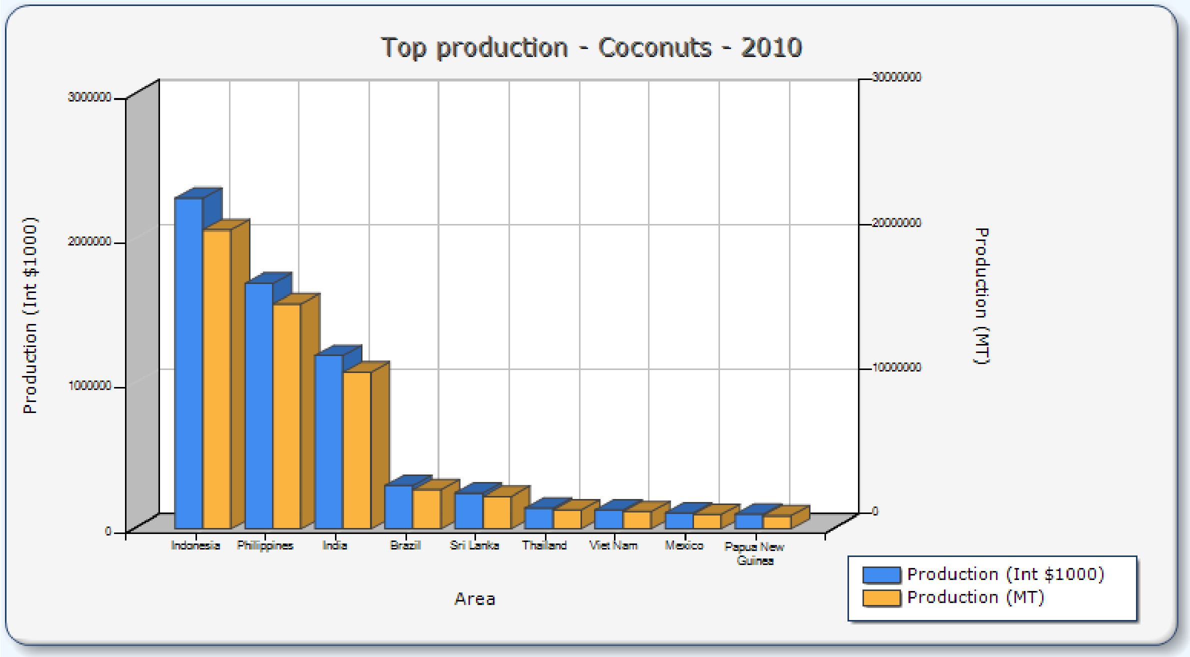

Figure 21 - Coconut production, by country, for year 2010. Source FAOSTAT, 2012.

A huge range of products can be made from a coconutõs husk, shell and the kernel and the price outlined in figure 11 indicates the current value of each major product. It shows the value of materials derived from the husk ï coir fibre and pith ï in relation to coconut oil and other food products.

Because of the strong price for coconuts and associated products, the increasing array of products derived from every part of the coconut tree and a growing domestic consumption, most of the major coconut-producing countries have plans to improve productivity of coconut production and to increase the volumes of coconuts grown.

The coconut can be considered to be quite a sustainable crop. The tree, for example the traditional ñEast Coast Tall Varietyò starts to produce nuts after 5 years and continues to produce inflorescence (flowers) every 40 days for the next 70 years. Plantations are set on standard 26ft tree spacing which gives approximately 70 trees per acre or 174/ha. A coconut takes 270 days to mature and depending on region and water scarcity produces between 10 to 20 coconuts per inflorescence. The average in India is 93 coconuts per tree/year[44] whereas Sri Lanka is 43 nuts per tree/year[45]. As most coconuts are grown in regions that benefit from one or two monsoons/year, there is often times of the year when there is an abundance of coconuts and times towards the end of the dry season when the yield is reduced but irrespective of the season, coconut palms are harvested every 40 days which produces a continuous supply of coconuts.

The demand for coconuts and its products is growing in many countries for both domestic and export markets. The coconut production expansion plans for India and Sri Lanka are described.

[44] Indian Coconut Board figures
[45] Coconut Development Authority figures

3.3.1.1. India's coconut industry

India's economy is based, in part, on planning through its five year plans. It is currently in its 12th five year plan which was launched in 2012.

The Coconut Development Board, established under the Ministry of Agriculture, Government of India is responsible for the integrated development of coconut cultivation and industry in the country and has developed a strategy to deliver the 12th five year plan. This focuses on promoting increased productivity, expanding coconut cultivation into non-traditional belts, diversification of coconut products, developing more innovative technology, increasing the export of coconuts, improving marketing to export countries, revitalising the cooperative and promoting women in the coconut industry.

The production of nuts increased steadily from 12535.0 million nuts in 1999 to 14743.6 million nuts in 2008[46].

The total area under coconut cultivation in India is 1.9 million hectares. The majority of coconuts (98%) are grown by small holders with areas of less than two hectares.

3.3.1.2. Sri Lanka's coconut industry

Sri Lanka's coconut production declined in Sri Lanka as a result of the recent civil war and people leaving their land[47]. Today the area under coconut cultivation is 0.39 million hectares. The majority of cultivation (82%) is undertaken by small holders with the remainder produced on larger estates[48]. Sri Lanka's Ministry of Coconut Development and Junatha Estate Development has a mission to increase the production, profit and sustainability of the coconut industry[49]. Their goals include increasing the production of nuts from 2.7 bn nuts to 3.5 bn between 2011- 2016; increasing the scale of plantation; organising the smallholder sector to alleviate poverty; increase productivity through diversification; develop an environmentally sound and economically viable coconut-based industry; generate new technologies to meet the changing needs of the coconut industry; and increase income generation by diversifying formal and informal sectors of coconut-based industries. Plans are underway to plant coconuts in the north and along the east coast of Sri Lanka.

3.3.1.3. Coconut production by smallholders

In both India and Sri Lanka coconut production is mainly by small holders. There are many socio-economic and ecological benefits for coconut production by smallholders.

Smallholders can adopt intensive land use systems that involve growing coconuts and bananas or other woody crops with herbaceous species, either with or without livestock and managed within the boundaries of individual houses. An assessment of the ecological and socio-economic benefits provided by homegardens in Kerala for example[50] , demonstrated that biodiversity parallels that of a natural forest; that the agroforestry approach is profitable

[46] Coconut Development Board. 2010.
[47] Personal communication, Botanicoir.
[48] Coconut Development Authority, Sri Lanka.
[49] http://www.cdjedmin.gov.lk/home/
[50] Mohan, S. 2004. An assessment of the ecological and socioeconomic benefits provided by homegardens: a case study of Kerala, India. *PhD thesis. University of Florida*. 2004.

to the farmer and supplies the family with the majority of their nutritional needs; and it supports the local community. Generally the homegardens are tended by females and the economic decision making in these households are shared equally between males and females. Land management of this type maintains the cultural and land management knowledge that has been passed down through the generations. These systems are economically stable and deal with the fluctuations in prices. Retaining homegardens is also more profitable than leasing or selling land, in which case farmers would have to become hired labour on neighbouring land.

That said not all small holders adopt intensive land use systems with many, particularly in Sri Lanka, opting for extensive, monoculture systems ï figure 22.

Figure 22 ï Extensive, monoculture coconut production.

It has been argued that linking farmers to the markets through efficient value chains would reduce the use of intermediaries in the chain, and strengthen the value-adding activities by better technology and inputs, upgraded infrastructure and processing and exports[51]. This process can raise the income of farmers and will provide incentive for improving their management practices towards higher farm productivity. The income of the farmers can be enhanced by increasing production, value addition, and better marketing options[52].

One study indicates that the nuts harvested by the farmers are sold through different outlets such as local vendors, mandi (state run agricultural markets), and commission agents. In Orissa 76 per cent of the producers sold their coconuts to the local vendors at farm gate. About 35 per cent of the farmers sold their produce in the local area by self-marketing. Only 16 per cent farmers used the regulated mandi for marketing their nuts.

[51] Miller, C. and Jones, L. 2010. A*gricultural Value Chain Finance – Tools and Lessons*. Food and Agriculture Organization (FAO), Rome.

[52] Kumara, M. and Kapoorb, S. 2010. Value Chain Analysis of Coconut in Orissa. *Agricultural Economics Research Review* Vol. 23 (Conference Number) 2010 pp 411-418.

3.3.2. Quality

Varieties of coconut palms are selected on the basis of productivity and ease of plantation management practices. This choice is entirely dictated by the use of the kernel as a food or food related product. The final use of the husk for either the coir or coir pith industry does not impact the production volume, management practices or markets at this stage of the supply chain.

3.3.3. Economy

The coconut is hugely important to the coconut growing regions mainly because of its total integration into the daily diets of the domestic population. Coconut production is highly significant for the rural economy of India and Sri Lanka both in terms of sustenance and income.

It is important to note that both India and Sri Lanka have specific Government departments for coconut production and the promotion of key products.

Due to its high domestic use India does not export coconut kernels and derives its main export income from coir fibre and coir products. Coconuts contribute approximately 0.2% of the Gross Domestic Product of India. The export of coconut derived products in Sri Lanka, on the other hand, contributes to 3.5% of total exports. Coconuts, in Sri Lanka contribute to 1.4% of the GDP.

The economics of coconut production and the subsequent processing of products is dependent on a number of factors. The location is important with high costs associated with the transport of coconuts making it more likely that those processing facilities located in close proximity to farms have better access and preferential trade relations than processing facilities located farther away. The availability of labour and competition from other industries for labour and a local market for the coconut and its associated products are also significant.

An exercise was conducted to ascertain the value of the coconut to the farmer so that a true share of the nut and husk could be defined. It was quickly identified that not only did the value of the coconut differ from one year to the next, but from trader to trader and from region to region and across countries. If a farmer harvested the coconuts and de-husked them, then the value would be greater than if he employed a trader to harvest, dehusk and sell his crop.

What was interesting was the ratio of the value between the husk and the nut[53]. In 2012, coconuts were being sold in Kerala for 6-8 rupees and husks for less than 1rupee. In the Pollachi area of Tamil Nadu, coconuts were reaching prices of up to 10 rupees - with a nut value of 9 rupees and a husk value of 1rupee. In other areas this value was confirmed with figures in 2011 of 10,500 rupees per 1000 nuts and 1050 rupees for 1000 husks. In 2012 this figure is 7500 rupees per 1000 nuts and 750 rupees per 1000 husks. They all follow the general trend that the price ratio of nut:husk is approximately 10:1.

For the purpose of this report, it was identified that the value of the husk is approximately 10% of the whole coconut. A similar ratio was also determined in Sri Lanka. In terms of the

[53] Private communication with coir pith and coir fibre producers, Government officials in India and Sri Lanka.

husk value is added through the production of fibre where the husk from one coconut can generate an income of approximately 1.47 Indian rupees and for coir pith 1.4 Indian Rupees.

The increased price of the nut versus the husks are explained by the market prices for each of the value add products ï figure 11.

3.3.4. Land use change

Land use change as a result of coconut plantation was not found to be a current issue in India and Sri Lanka. There was no evidence that natural habitat was replaced directly by coconut plantation[54]. Plans to extend coconut plantations into the non-traditional areas in India and Sri Lanka are specifically on degraded lands or lands already used for the growth of other crops. The plans for the future expansion of coconut lands in both countries will focus on degraded lands, existing agricultural land and land where cultivation of other crops is not possible as coconuts can thrive on lower quality soils.

India and Sri Lanka heavily protect their existing forests by law in reserves. The forests of both India and Sri Lanka are known as being some of the worldôs greatest biodiversity hotspots.

Another forest type of importance is the mangrove forest, with many coconut plantations developed near the coast. The ingress of coconuts into the mangrove forests generally started with rice and bean cultivation which was then followed by coconut[55]. Sri Lanka has lost 95% of its native mangrove areas, mostly as a result of prawn farming and urbanisation. Care needs to be taken by responsible supply chains to assure that raw materials are not derived from companies that are involved in the further destruction of these areas.

The expansion of coconut plantation in other countries, particularly the Philippines and Indonesia, might present a more significant land use change. Large scale deforestation has already occurred as a result of oil palm plantation. It appears that the more destructive land use changes because of coconut growth took place in the past when lowland forests and peatlands were converted to coconut plantations[56]. This issue is largely confined to Indonesia, particularly Sumatra and Kalimantan, when many large forests and peat land areas were converted for coconut growth between 1965 ï 1990, at the height of spontaneous and official transmigration. The leading sectors in land conversion today are oil palm and pulpwood (Acacia). There is little evidence that destructive land use change resulting from coconut planting is happening, although this will always need to be rigorously verified in these countries as they are considered very high risk in this respect.

In summary, only sparse data exists for land use change as a result of coconut plantations. Extrapolating the findings from the studies on oil palm and coconut plantations in the Pacific it is clear that coconut plantations should not replace peatlands or natural forest and that higher density plantations can lead to the collapse of complex ecosystems and loss of biodiversity. The same is likely to hold true for the dense planting of many monoculture crops.

---

[54] Personal communication with international and local NGO's in Sri Lanka.
[55] Marcel Silvius, Wetlands International, personal communication.
[56] Marcel Silvius, Wetlands International, personal communication.

3.3.5. Water, soil and air pollution

The potential sources of water, soil and air pollution rise from inputs such as fertilizer, herbicide and insecticide. Each of these were explored during the onsite visits, conversations with scientists in Sri Lanka and a scientific literature survey .

3.3.5.1. Fertilizer

Coconut palms do remove nutrients from the soil. For example, the coconut palm producing 50 nuts per year removes the following plant nutrients in the soil ï nitrogen (480g); phosphorous (55g); potassium (900g); and magnesium (180g).

In addition to the uptake by the palm, soil nutrients can be lost by run-off, leaching, erosion and uptake by weeds. This leads to a gradual depletion of essential plant nutrients in the soil, impacting on the yield of nuts. Therefore soils in coconut plantations need to be enriched with nitrogen, phosphorous, potassium and magnesium by regular fertilizer application.

Fertilizer is therefore widely used. Coconut palms can be fertilized using either organic or inorganic fertilizer.

Inorganic fertilizers utilise rock phosphate, urea (nitrogen), potash (potassium) and dolomite (magnesium) to make up the NPK mix. The application rates are generally determined by the rainfall characteristics of the area. The general recommendation is to use palm fronds as mulch immediately after the application of fertilizer to suppress ammonia emissions from the breakdown of urea, weed growth and to conserve soil moisture and increase organic matter in the soil.

The continuous use of organic fertilizers tends to increase the humus content of the soil and supply of plant nutrients. This benefits the soils and plants by improving the water holding capacity, aeration, structure, microorganism density, microbiological activities and the nutrient retention of the soils. It also maintains the soil pH and temperature at favourable levels to the coconut. Application of organic manure would increase the nut yield by 15-20% and copra yield by 20-25%[57].

3.3.5.2. Insecticides

Coconuts palms do suffer from the detrimental effects a number of insects and fungal diseases controlled through biological control or the use of insecticides.

The red weevil is the most serious pest in young palms and the rhinoceros beetle is a major pest occurring in most coconut growing areas. Both have chemical treatments available to reduce infestations.

3.3.5.3. Herbicides

Weed control in coconut plantations fall in to three broad categories ï mechanical, chemical and cultural methods. The most commonly used herbicide is glyphosphate. From an environmental perspective, glyphosphate and its derivatives adsorb strongly to soil and, as a

[57] 'Use of organic manure for coconut'. 2006. Advisory Circular No. A6. Coconut research Institute of Sri Lanka.

result, are not expected to enter groundwater. It does have the potential to contaminate surface water, where it would not be readily broken down by water or sunlight.

Glyphosphate is only slightly toxic to birds and almost non-toxic to fish and aquatic invertebrates.

3.3.5.4. Water pollution

The run-off of fertilizers, insecticides and herbicides from coconut plantations is likely to be much lower than that from intensively produced crops in India and Sri Lanka. The risk of environmental impact is considered to be relatively low.

3.3.5.5. Soil conservation

With the majority of coconuts grown on flat lands in India and Sri Lanka the issues of soil erosion and land degradation as a result of coconut plantations generally do not often arise ï compared to other crops such as tea or rubber plantations which are often grown on slopes. This does not however hold true for other countries, for example the Philippines where 30% of the coconut lands are in mountainous areas[58], often exacerbated by being in areas with heavy rains which can remove large amounts of topsoil.

Soil conservation practices are important and include ground cover by other crops and grasses, drainage and terracing. Drainage is useful for reducing soil erosion and increasing moisture conservation. Evidence of the use of ground cover crops was observed in India and Sri Lanka but was by no means used in all coconut plantations.

Coconuts also remove soil nutrients over the long lifetime of the palm. Young et al[59], demonstrated that forests with a higher abundance of coconut palms affect soil properties by reducing the availability of macronutrients (nitrate, ammonium and phosphate) when compared to forests with a lower abundance of coconuts. Coconuts require very few nutrients to thrive and are highly efficient at nutrient cycling, leading to nutrients leaching out of soils and ultimately nutrient poor soils. The input of nutrient is therefore required over the life time of a plantation and both organic and inorganic NPK-based fertilizers are used. The impact of the intensive use of inorganic fertilizers in terms of reduction of soil organic matter, pollution of water are well documented.

Monoculture plantations present the more significant risks to soils. In Sri Lanka, approximately 75% of coconut lands are monoculture (including smallholder cultivation practices). The Sri Lankan Government are actively pursuing initiatives to promote the multiple social, economic and environmental benefits of intercropping to coconut farmers. Previously the Government has subsidised intercropping but the current economic climate has mean that this has not continued. The reverse is true in Kerala, for example, where the majority of coconuts are produced in home-gardens which are planted with other crops and

[58] Pabuayon, I.M., Medina, S.M., Medina, C.M. and Manohar, E.C. 2009. The Phillipines' regulatory policy on coconut cutting: an assessment incorporating environmental consideration. *J. ISSAAS Vol. 15, No. 2:93-106.*
[59] Young, H.S., Raab, T.K., McCauley, D.J., Briggs, A.A., and Dirzo, R. 2010. The coconut palm, Cocos nucifera, impacts forest composition and soil characteristics at Palmyra Atoll, Central Pacific. *Journal of Vegetation Science:* 1–11.

fertilised using organic fertilizers. Fertilizer regimes that use more organic fertilizer, supplemented by inorganic fertilizer, deliver the most benefits to the health and productivity of the coconut and to the environment[60].

In India some coconut producing states have significant conservation issues with soil as a result of general agricultural practices. In Tamil Nadu for example, intensive cropping, the indiscriminate use of chemical fertilizers and inadequate availability of organic manures has led to a reduction in the soil organic matter content from 1.20% in 1971 to 0.68% in 2008[61]. The Government is promoting better use of organic and inorganic fertilizers by issuing soil health cards to all farm holdings in Tamil Nadu to improve the land management practices of farmers.

3.3.5.6. Air pollution

There is very little potential for air pollution resulting from the cultivation of coconuts and so this was not considered a risk.

3.3.6. Biodiversity

Few studies on the impact of coconut plantations on biodiversity have been identified. There are however a number of studies on oil palm plantations that can be used as a useful indicator of potential impacts.

A number of studies indicate that biodiversity is significantly lower in oil palm plantations than natural forest and that species composition can be different. Koh and Wilcox (2008)[62] showed that the species richness of forest birds is decreased by 70% following conversion of primary and selectively logged forest to plantation. They also found that butterfly species were reduced by 80%. Danielson et al (2009)[63] determined that vertebrate species richness of palm oil plantations is 38% that of natural forests, whilst only 23% of a forests vertebrate species are found in plantations Fitzherbert et al (2008)[64] found that across all taxa a mean of only 15% of species found in primary forest remain in oil palm plantations, whilst many species found in plantations are not found in natural forests, and in some cases are not indigenous to the region. The species found in both the forests and plantations had to be generalists, whilst species with specialised diets or dependent on niche habitats are not found in plantations.

A few studies indicate that the biodiversity effects of palm oil plantations are also seen in coconut plantations. One study found that the coconut palm caused a significant decline in floristic species and that the extent of this decline was dependent on the relative abundance

---

60 Mantiquilla,J.A., Canja, L.H., Margate, R.Z. and Magat, S.S. 1994. The use of organic fertilizer in coconut. Philippine Journal of Coconut Studies. Vol. 19 (1). Pg 8-13.

61 Government of Tamil Nadu, Agriculture Department, Policy Note, Demand No.5 – Agriculture, 2011-2012.

62 Koh, L.P. and Wilcove, D.S. 2008. Is oil palm agriculture really destroying tropical biodiversity? *Conservation Letters* 1, 60–64.

63 Danielson, F., Hendrien, B., Burgess, N. D., Parish, F., Brühl, C. A., Donald, P. F. 2008. Plantations on Forested Lands: Double Jeopardy for Biodiversity and Climate. *Conservation Biology,* 23(2), 348-358).

64 Fitzherbert, E.B., Struebig, M.J., Morel, A., Danielsen, F., Bruhl, C.A., Paul F. Donald, P.F. and Ben Phalan, B. 2008. How will oil palm expansion affect biodiversity? *Trends in Ecology and Evolution* 23 538 – 545.

of coconut palms[65]. They found that diversity is significantly higher in low/intermediate density forests. The understorey of coconut palms are nutrient poor, they have high shading and very little biomass apart from dead fallen strands. Coconut palms change the nutrient cycles which leads to the collapse of whole food webs and much simpler ecosystems[66].

Coconut palms trend towards mono-dominance and native plants find it very difficult to establish in a palm forest. So the coconut palm is a range expanding species which can outcompete native plants. The greatest biodiversity impacts occur when coconut palms are introduced to non-native areas, where they can cause the collapse of more complex ecosystems.

Inter-cropping with other crops present an opportunity for increasing biodiversity, although the minimum impact on biodiversity will be seen in home gardens as described in 3.3.1.

Coir pith production takes place in areas of high concentration of coconut growth, where the economies of scale for processing can be made. These areas are generally a mix of many smallholders and plantations that practice inter-cropping and monoculture in India and Sri Lanka.

3.3.7. Water consumption and conservation

Coconut palms require a regular supply of water to maintain a consistent nut production throughout the year. In Pollachi, Tamil Nadu, for example each tree needs between 40 -100 litres of water a day. The coconut palm has shallow roots that radiate 2 m from the trunk and do not penetrate further than 2 m below the soil surface ï figure 23. The part of the root that absorbs water is a 2 ï 5mm region just behind the growing tip of the root. When soils are dry for a long period of time this area grows a thick protective layer which can no longer absorb water. This process is not reversible and so during rain free periods the conservation of soil moisture in coconut lands is therefore critical.

Figure 23 – Root system of the coconut palm.

[65] Young, H.S., Raab, T.K., McCauley, D.J., Briggs, A.A., and Dirzo, R. 2010. The coconut palm, *Cocos nucifera*, impacts forest composition and soil characteristics at Palmyra Atoll, Central Pacific. *Journal of Vegetation Science: 1–11.*

[66] Personal communication, Hillary Young.

The key water conservation methods include reduction of water evaporation from soil, mulching the area around the trunk, management of crop cover, adoption of good weed management practices, improving the water holding capacity of soils, application of organic matter and burying coconut husks in pits.

Mulching can either utilise coconut fronds or husks. The latter have fertilizer properties and high levels of potassium. About 100,000 husks contain the equivalent of 1 MT of potash.

Husks are generally promoted for use in the sustainable management of plantations. Generally, they can absorb and retain up to six times their weight of water in the wet season and release it slowly during the dry season. Their spongy structure also supports root growth. They are either buried in husk-pits arranged between each palm or in linear trenches between alternative rows of palm.

The use of cover crops is one of the most effective means of conserving water in plantations. They help control surface run-off and erosion, provide a large quantity of mulch, improve soil structure and infiltration of water, reduce the leaching of nutrients, soil temperature and weed control and leguminous cover crops provide nitrogen to the soil.

Coconut palms require plenty of water. The availability of water is essential for determining the size of the coconut. National coconut production varies widely depending on the weather conditions. In some years, in Sri Lanka for example, the loss has been up to 30% of its production as a result of drought[67].

Every palm needs, on average 40 -100 litres of water a day. In Sri Lanka and India the major source of water used in coconut plantations is from private boreholes or wells. Rainwater harvesting is practised in some estates although it was not extensively observed.

Water consumption is therefore high for coconut growth and the availability of water is a significant consideration.

The water availability in both India and Sri Lanka has been previously discussed. In India, particularly Tamil Nadu it is anticipated that water will become more of a significant issue in the future. The Government is financially and technically supporting the farmers to buy and use water efficient drip irrigation systems. Similarly, in Sri Lanka, although there is a much lower level of concern in the dry zones particularly it is important to utilise efficient irrigation systems and to adopt water conservation methods on plantations.

Over 70% of coconut production occurs in Sri Lanka in the north and central west coast districts of Kurunegala, Puttalem, Gampaha and Colombo with a significant percentage of the remainder produced in Kalutara, Galle, Matara and Hambantota on the south and south eastern coast. Three of these areas, Kurunegala, Puttalem and Hambantota are in the dry zone. Some of the major coir pith producing areas fall into the dry zone and so water conservation measures are highly recommended.

[67] Advisory Circular No A9. 2006. Coconut Research Institute of Sri Lanka.

3.3.8. Energy consumption

On coconut plantations the main use of fossil fuels would be for pumps to extract water from boreholes and wells, which is subsidised by the Indian Government. No meters were observed to calculate plantation energy consumption. A further energy use would be their transportation post harvest.

3.3.9. Cultural

The coconut is a huge culturally significant crop in both India and Sri Lanka. It not only provides food for many households it has a deep religious and social significance.

In India the coconut is known as the óKalpavrikshaô, the tree which helps fulfil all desires of mankind. The coconut is used at most auspicious and religious occasions ï births, marriages, new homes and cars, opening ceremonies of new businesses. The coconut signifies prosperity and is offered in most temples as a symbol of the completeness of life.

In India the coconut is the favourite fruit of all the deities and is used in large volumes at every festival ï Diwali, Dussera, Ganesh Puja, Durga Puja and Holi ï where it is offered to gods and guests alike. At the largest festival, the Nariyal Purnima or the Hindu month of Shravan, the full moon of this month is the closest to the end of the monsoon. At this time thousands of fisherman on the west coast of India offer coconuts to the sea before resuming their fishing operations after the monsoon for prosperity and safe travels.

The coconut is also well known for its medicinal qualities.

3.3.10. Rural economy

Every part of the coconut tree is utilised ï timber for construction, fronds for shading and roof material, stems of the fronds for biomass to name a few. There is a vast array and volume of industries associated with coconut production, value addition and how the products are traded and transported.

The benefits of coconut production on the rural economy is best explained by the following simple case study of a coconut farmer in Tamil Nadu gained during the on-site visit.

A village leader near Pollachi, Tamil Nadu, explained the impact of his coconut to coir pith supply chain on the local rural economy. The example below is based on the labour following one day of harvesting 5000 coconuts and sending them to a mechanised fibre mill.

One person harvests 5000 coconuts/day	=1 days employment
1 person follows harvester and collects 1000 coconuts/day	=5 days employment
1 person loads/moves husks	=1 days employment
1 person can de-husk 1000 coconuts/day	=5 days employment
1 labourer for loading 5000 nuts/husks/day	=1 days employment
1 lorry driver to deliver 5000 husks and nuts to mills	= 1 days employment
1 un-loader/sorter at fibre mill unloads 5,000 nuts	=1.5 hrs
4 staff process 5,000 husks at mill per day	=4 days employment
	----------------------------
	=18.1 days employment per 5000 coconuts

During on-site visits to a village leader's coir fibre mill it was established that his mill processed 30,000 coconut husks a day and there are almost 200 similar mills in the district which is dependent on agriculture for its income. This gives an insight in to how important this industry is to the rural economy.

3.3.11. Working conditions

As part of the informal industry very little scrutiny exists in coconut plantations. Generally, working practices are not governed by local laws leading to a higher potential for un-ethical practices to exist. The numbers of people involved in the coconut plantation industry are large with Sri Lanka's Coconut Research Institute estimating that 700,000 workers are engaged in coconut cultivation on a part-time basis.

Tree climbing and harvesting coconuts is a skilled job and one where skilled labour is in decline and so wages are commensurate with the skills and inherent risks involved in tree climbing – figure 24. All other tasks within the coconut plantation do not require skilled labour. The farmer may sell their crop to a trader who brings in their own labour to harvest and remove the crop or the farmer may harvest the crop by themselves and sell to mills or other traders. Very little evidence was available to confirm wage structures and payment methods.

Figure 24 ï Tree climbing and coconut harvesting are skilled jobs and the availability of skilled labour is in decline.

One of the processes used in the coconut industry is de-husking - the removal of the nut from the husk. It is a very physical job carried out by hand in hot conditions under partial shade/full sun.

The most likely occurrence of young workers in plantations exists within the family structure of a small holding where the whole family are engaged in activities to support the family income ï which by international standards is generally seen as positive[68]. No evidence was established to show a common trend of children working and not attending school. It was noted that for the areas visited during the onsite assessment the literacy rates were high. In Sri Lanka the national literacy rates were up to 95%. In Kerala this was 94% with Tamil Nadu at 80% - compared to a national average of 74%. All indicate a high level of school attendance in the coconut and coir producing areas. Anecdotal evidence was established that where families lived in the grounds of larger plantations, issues of bonded labour or where children were working in hazardous conditions[69] such as retting pits were more likely to exist, if it existed at all, but no factual evidence was established to support this.

---

[68] ILO definitionhttp://www.ilo.org/ipec/facts/lang--en/index.htm. ''Children's or adolescents' participation in work that does not affect their health and personal development or interfere with their schooling, is generally regarded as being something positive. This includes activities such as helping their parents around the home, assisting in a family business or earning pocket money outside school hours and during school holidays. These kinds of activities contribute to children's development and to the welfare of their families; they provide them with skills and experience, and help to prepare them to be productive members of society during their adult life''.

[69] ILO definition http://www.ilo.org/ipec/facts/lang--en/index.htm ''Labour that jeopardises the physical, mental or moral well-being of a child, either because of its nature or because of the conditions in which it is carried out, known as "hazardous work".

4. SIGNIFICANCE OF RISKS AND IMPACTS AND SUSTAINABILITY HOTSPOTS

Using the information gathered from the literature review and the on-site visits to coconut producers, coir pith processors, coir fibre mills and key stakeholders in India and Sri Lanka the significance of the impacts identified in the supply chain of coir pith that potentially enters the UK market was determined using a simple risk matrix.

The sustainability indicators were assessed for each of the supply chain tiers in terms of likelihood of the risk occurring and the impact if it did. A simple score of high, medium, low and zero was used for each, with numerical values in brackets ascribed to each i.e. low = 1, medium = 2 and high = 3. The results are presented in figure 25.

Phase of supply chain	Sustainability indicator	Likelihood of impact on sustainability of coir pith supply chain			Impact on people, environment or economics (negative or positive)			Total raw score	Weighted score
		L (1)	M (2)	H (3)	L (1)	M (2)	H (3)		
Tier 3 - Coconut production	Availability of coconuts	0					-ve	0	0
	Quality	X			0			0	0
	Economic viability	0			-ve			0	0
	Biodiversity		X			-ve		- 4	-0.2
	Land use change	X				-ve		-2	-0.1
	Pollution of water, soil or air	X				-ve		-2	-0.1
	Water consumption		X			-ve		-4	-0.2
	Energy consumption	X			-ve			-1	-0.05
	Culture	X					+ve	+3	+0.15
	Rural economy	X					+ve	+3	+0.15
	Working conditions	X			-ve			-1	-0.05
Tier 2 - Coir fibre production	Availability	0					-ve	0	0
	Quality	X					-ve	-3	-1.5
	Economics	X			-ve			-1	-0.5
	Biodiversity		X				-ve	-6	-3
	Land use change	X			-ve			-1	-0.5
	Pollution of water, soil or air		X				-ve	-6	-3
	Water consumption	X			-ve			-1	-0.5
	Energy consumption	X			-ve			-1	-0.5
	Culture	X			-ve			-1	-0.5
	Rural economy	X					+ve	+3	+1.5
	Working conditions			X			-ve	-9	-4.5
Tier 1 - Coir pith processing	Availability	0					-ve	0	0
	Quality	X					-ve	-3	-3
	Economics	X			+ve			+1	+1
	Biodiversity	X				-ve		-2	-2
	Land use change	X			-ve			-1	-1
	Pollution of water, soil or air		X			-ve		-4	-4
	Water consumption		X				-ve	-6	-6
	Energy consumption	X			-ve			-1	-1
	Culture	X			-ve			+1	+1
	Rural economy	X					+ve	+3	+3
	Working conditions		X				-ve	-6	-6

Figure 25 - A risk matrix for the coir pith supply chain. Key: 0 = no risk; X = identifies the likelihood of risk as low, medium or high; and –ve or +ve = a negative or positive impact in the low, medium or high category. Each category was ascribed a numerical value from1-3 (in brackets). The 'total scores' were calculated by multiplying the likelihood scores with the impact score. The 'total scores' were then weighted according to the allocation of the impacts that could be attributed to coir pith (100% in Tier 1; 50% tier 2; and 5% tier 3). Sustainability hotspots are those that have a weighted score of -4 or below.These are highlighted in red.

The sustainability hotspots in the coir pith supply chain are identified as those with negative scores of minus four and below, after the allocation for coir pith has been calculated for each score in each tier. The rationale for this cut-off was that a significant sustainability impact occurs when a sustainability indicator is medium for likelihood (with a numerical value of -2) and medium for severity of impacts (with a numerical value of -2), leading to a multiplied value of -4. Clearly if either of these scores moved to high (with a numerical value of -3), the total score would be more negative. The weighting was then used to allocate the total score to coir pith. So, in the case of scores for tier 2 the total score would have to be reduced by 50% to properly attribute the impact to coir pith. Similarly with tier 3, where only 5% of the total score can be attributed to coir pith.

The sustainability hotspots for coir pith

4.1. Tier 1 ï coir pith processing

100% of the impacts of processing coir pith can be directly ascribed to coir pith. The most significant negative impacts of coir pith processing are:

- the consumption and management of water
- working conditions
- pollution of water and soils

Coir pith processing does also have a number of positive scores in the sustainability assessment, as follows:

- removal of a significant environmental hazard
- contributor to rural economy

Other sustainability indicators worth highlighting for discussion include the availability and quality of coir pith. The evidence on the ground suggested a plentiful supply of high quality coir pith. The availability and quality of coir pith was seen to have a low likelihood of becoming a risk in the supply chain. Issues over supply generally seemed to arise because of a misalignment between the lead in times of buyers requesting large shipments and the drying season in Sri Lanka and India. Coir pith production is seasonal although there was evidence during onsite visits that many coir pith companies were moving towards continuous production through innovations in their processing methods. Large amounts of finished product are rarely stored in bulk by coir pith producers, although there were examples where graded, semi-processed pith was bagged and stored prior to the rainy season. The more streamlined that ordering process is the less likely there will be supply issues.

4.2. Tier 2 ï coir fibre processing.

Coir fibre processing happens whether the coir pith is utilised or not. In India and Sri Lanka coir pith is genuinely seen as a waste product from coir fibre processing and not as a by product. Neither country would envisage coir fibre as a waste product to coir pith ï if the economics tipped in that favour in the future. The whole coir fibre extraction process is designed for the maximum efficiency and quality of fibre only.

That said economic value has been used to apportion the relative impacts of coir pith. Coir pith is therefore responsible for 50% of the following impacts.

The sustainability hotspots in fibre processing that can are relevant to the coir pith supply chain are working conditions in the fibre mill. This is most relevant for mills in the informal sector and mills in Sri Lanka that use the spinning nail drum.

- Working conditions

The other impacts of coir fibre production are important but not considered sustainability hotspots. It is worth explaining this conclusion more for the subject of retting.

- Environmental, soil and air pollution

The most difficult aspect of coir fibre production to generically ascribe an impact to, is retting. Where traditional nine month retting does occur the pollution of water, soil and air is high, as is the impact on ecosystems, biodiversity and habitats. The processes used to make coir fibre and the likelihood of pith being collected from each of these processes and entering the UK supply chain need to be carefully considered before an assessment is made.

In India the predominant fibre processing system from which coir pith is collected is the mechanised decorticator. In this system retting is not present and neither are the associated environmental impacts. The brown husks are only wetted or soaked for a short time. There is less concern about environmental pollution in the mechanised process, although clearly any environmental impacts could be reduced by ensuring that any effluent from soaking or wetting is treated appropriately.

Retting does occur in India, often in ecologically sensitive sites, but it is associated with the traditional production of coir fibre. Where traditional retting was witnessed during the visit to India and Sri Lanka the pith was not utilised other than to help weigh down the coconut husks in the water and to provide pathways through the retting pools. The quality of pith following this long soaking is also of poor quality, particularly with respect to its physical properties. The use of pith from traditionally retted coir fibre is assessed to be highly unlikely to be present in UK supply chains from India.

In Sri Lanka, where the level of mechanisation is lower at 20 ï 30% of mills, the retting process is more common, although generally the husks are soaked for two months and not the nine months described above. Clearly, this presents an environmental pollution risk if the retting process is not contained in bunded tanks or frequently flushed through and if the effluent is not appropriately treated.

Although retting was not identified as a sustainability hotspot for the coir pith processors, because the likelihood of it being part of the supply chain for higher volumes of coir pith is lower, it does urgently need to be addressed by the coir fibre supply chains. Retting is a direct requirement of some fibre production systems. Responsible coir pith processors should identify any retting in their supply chain and work with their suppliers to improve water management practices throughout the retting process used for fibre production.

Coir fibre production also brings many benefits through making a large contribution to the culture and rural economy in fibre producing regions. Coir fibre processing, weaving and rope making are the traditional industries in many parts of India and Sri Lanka and form a significant part of their cultural heritage as well as a highly significant contributor to a poor rural economy.

4.3. Tier 3 ï coconut production

Using the economic valuation model the relative contribution that coir pith has on coconut production is 5%, so very low. No sustainability hotspots were identified in this tier.

There are no impacts assessed to be of high significance, other than the huge cultural, religious and social importance of the coconut tree in the lives of those living in coconut producing countries.

The impacts of note include the following:

- Irrigation

The coconut tree requires irrigation, particularly in Tamil Nadu, India, which is a water stressed area. Rainwater harvesting, efficient irrigation techniques and water conservation practices should be adopted in these areas.

- Biodiversity

In recent history, neither India or Sri Lanka have cleared areas of high biodiversity to plant coconut plantations. Generally the plantations have replaced other agricultural crops or have been planted on degraded lands. The fact that a significant proportion of coconuts used by the coir fibre industry are grown as a monoculture crop present more of an issue for reducing biodiversity. The real opportunity for coconut plantations though is that the adoption of intecropping presents the opportunity for more intensive land management bring economic benefits as well as improving biodiversity. It will be the respective Governmentsô responsibilities to promote this, rather than something that the coir pith processors can influence.

5. DISCUSSION

This study set out to map the UK supply chain of coir pith and identify all stages, processes and actors. Then to establish the inputs and potential impacts throughout the supply chain and, using a literature review and on-site visits to India and Sri Lanka, determine the likelihood of them occurring and the impact. From this the sustainability hotspots for the coir pith supply chain could be determined. The study also set out to identify best practice in the supply chain.

5.1. Establishing the coir pith supply chain

The coir pith supply chain was established through the on-site visits to coconut plantations, coir fibre mills and coir pith processors in India and Sri Lanka and conversations with UK growing media producers and importers.

This was a critical exercise that identified that the coir pith supply chain can be split into three tiers ï coir processing, coir fibre production and coconut production. This greatly simplified the sustainability analysis, attribution of impacts and suggestions for improvement. It also helped to identify a number of processes for producing coir fibre ï the traditional retting and hand beating, shorter term retting and machine or dry milling - which was critical for understanding the impacts of coir pith supply chain.

5.2. Sustainability assessment

An assessment method and set of indicators was developed to capture all of the impacts, positive as well as negative. The assessment was based on the coir pith industry and the generic supply chain rather than focus on one supply chain specifically.

In undertaking the assessment it was clear that there are large variations in the performance of businesses. This variation depended on the country in which the business operated, the scale of the business, ownership, management and length of time established. When the industry overall scored badly on one sustainability indicator in this assessment it doesnôt mean that all businesses within the sector should be tarred with the same brush, as there was plenty of evidence of good practice. Where risks in the industry are identified as significant however, there is generally a higher risk that this will be found in more supply chains. Whilst a report of this nature required a generic assessment of the industry it is critical that UK businesses take their own steps to identify specific challenges and opportunities within their own supply chain in the future. The current assessment provides the framework for identifying risks.

In terms of availability and quality of coir pith the onsite assessment established that there were a number of medium to large scale operations in India and Sri Lanka capable of continuing to supply the UK with its high quality requirements. Most of these operations were scalable according to demand. So greater demand from the UK, along with plentiful supply of raw material, was not seen as an issue in this assessment.

In terms of sustainability hotspots of the coir pith supply chain these were identified as:

- Tier 1 (coir pith processing) ï working conditions, water consumption and the pollution of water and soil by the washing and buffering processes.
- Tier 2 (coir fibre extraction) ï working conditions.

The majority of coir pith processing units visited needed to address water consumption, conservation and pollution of the environs through the release of untreated effluent. There was one example of good practice in India that had addressed these issues and were conserving over 60% of the water. Most processors also needed to address the issue of reducing the amount of coir dust in the working environment and to undertake ethical audits to assure good working conditions in pith factories. As coir pith processors are responsible for 100% of the impacts of their operation these areas are directly their responsibility.

Coir fibre production is the tier where there is a clear difference in the impacts between India and Sri Lanka, also where the coir pith supply chain is responsible for only a proportion of the impacts. The results of this study suggest that the key sustainability hotspot for the coir pith supply chain is working conditions in the fibre mill which clearly the coir pith processor needs to play a part in addressing. In Sri Lanka the needle drum tends to be used for fibre extraction. There are also other significant health and safety considerations in many of its coir fibre mills. The Sri Lankan Government is aware of this and is addressing the issue at pace through investment and education. Sri Lanka also has a proportionally larger informal sector which means that industry within this sector is unregulated. Its formal sector is very effectively regulated ï for labour and environmental issues. If a mill is within the formal sector the concerns would be less. Further work is required to establish how much of the coir fibre industry is in the informal/formal sector. It is possible for responsible coir pith processors to chose to work with more responsible mills and to work more in partnership with them to improve practices. This can either happen voluntarily or if the customers of the coir pith request it. Clearly the coir fibre industry should also take a lead on this issue. The ILOÕs guide on good working practices in fibre mills comprehensively covers the issues.

Although not identified as sustainability hotspots there are clearly other significant sustainability issues in the supply chain to consider, particularly retting.

The mechanised decorticator processes husks without requiring a retting process. In India the coir pith is more likely to be a product of this process rather than a retted process because of the volumes and scale of decortication involved in its fibre mattress and pith industries. The uptake of this technology is higher in India than Sri Lanka and so the risk is considered to be generally lower (although each supply chain would need to be investigated to be sure that retted material was not used). Sri Lanka recognises the benefits of the decorticator and its use is becoming more widespread to increase productivity and to produce more mattress fibre.

Ideally the coir pith processor needs to work with their suppliers to reduce any issues of retting. Equally, customers need to be aware of the risk of retted material in their supply chain and promote the use of alternatively sourced coir pith.

Few significant risks were identified for coconut production and in any case the proportion of the impact that can be attributed to coir pith is small (5%) because the main product categories for coconut are related to food.

As has been previously mentioned good practices were observed in a number of areas as follows:

- Quality control in many of the coir pith processors visited
- Water conservation during coir pith processing
- Effluent treatment from coir pith processing
- Compliance with labour laws and environmental laws in the formal sector and
- Traceability

The importance of coconut production for sustenance and income is unquestionable. The coir fibre industry is extremely important to the rural economy and the rural poor and for particularly women. The coir pith industry is critical for bringing more income to the rural communities and ensuring that the coir fibre industry remains profitable.

Overall, the sustainability issues in the coir pith supply chain can be addressed through the collective efforts of the coir fibre industry, governments, coir pith processors and the UK customers. If the issues are addressed the growing coir fibre and pith industries will truly benefit the rural economies of those countries involved.

6. SUGGESTIONS

The following suggestions are made:

- The key sustainability hotspots for the coir pith supply chain should be directly addressed by the coir pith processors with the support of their customers and governments. UK growing media manufacturers and growers should request that the coir pith processors in their supply chain undertake an independent and internationally recognised ethical audit to address to key concerns identified through this study. Audits should use existing guidance such as those recommended by the International Labour Organisation. Pith processors should work closely with their main sources of pith to ensure that improvements are made in the working conditions of fibre mills. This will ensure that the rural economy fully benefits from the growing coir pith industry through the opportunity that pith producers have to question the working conditions in fibre mills, that have been described as both óappallingô and óunsatisfactoryô by the ILO, and to make it clear to their supply chain that this is unacceptable. Water management practices in pith processing is very important to address whether the pith processing is undertaken by a coir fibre mill or by the pith exporter. This should critically address the consumption and conservation of water and the treatment of the effluent from washing and buffering.

Coir pith processors also have the opportunity of supporting the coir fibre extraction industry address its key sustainability issues, namely 2 month retting and the working conditions in the fibre mills.

- As some of the major environmental and ethical impacts are concerned with **coir fibre** supply the coir fibre supply chain in the UK should be made aware of these impacts and how to address some of the key issues, in line with their responsible procurement policies.

- UK growing media manufacturers and growers should request traceability of their materials as a pre-requisite for their coir pith suppliers to source their raw material from coir fibre mills that undertake responsible ethical and environmental practices. As has been previously discussed the presence or absence of retting from a supply chain needs to be determined and addressed for each supply chain and coir pith processors can play a big role in this.

- Retailers of coir pith products should ensure that they embed their ethical and sustainable procurement policies into the coir pith supply chain.

ANNEX 1 Environmental and labour laws in India and Sri Lanka.

Both Sri Lanka and India have adequate labour and environmental laws in the formal sector of their economy as outlined below.

The risks arise in the informal sectors of their economies. The informal sector refers to the part of the economy that is untaxed, not monitored in any form by the government and not included in the Gross National Product calculations. The informal sector is prevalent in all developing countries and falls outside of the modern industrial sector. It comprises the self-employed workers, home-workers and both wage earners and non wage earners. The largest population in this sector is female and so raises significant concerns over gender effects.

The size of the informal sector in India and Sri Lanka has been estimated as 22.4% and 43.9% respectively of Gross Domestic Product[70].

The following describes the legislation that is applied to the formal sector. None of this however will be applied to the informal sector. Further work would need to be undertaken to understand how much of the coir pith supply chain falls into the formal and informal sector. The larger coir pith producers visited were in the formal sector but the smaller suppliers, including the coir fibre mills, are unlikely to be in the formal sector hence the significant issues identified.

A1.1. Environmental and labour legislation in Sri Lanka

The following provides a summary of the legislative context for Sri Lanka.

Sri Lanka has ratified International Labour Organisation's (ILO) conventions.

Sri Lanka has guaranteed freedom of association by Article 14 of the Constitution and trade unions are legislated under the Trade Union Ordinance of 1935 which provides for the registration and control of Trade Unions. Sri Lanka has also ratified ILO Conventions on Freedom of Association (C187) and Collective Bargaining (C98).

ILO Conventions on Equal Remuneration for Men and Women for work of equal value (No. 100), Maternity Protection (No. 103), Labour Statistics (N0. 160) were ratified in 1993. In 1984 Sri Lanka withdrew from the ILO Conventions (Nos. 4,41 and 89) prohibiting nightwork to enable night shifts in Export Promotion Zones.

The UN Convention on Elimination of all Forms of Discrimination against Women (CEDAW) has been ratified and A Women's Charter of Sri Lanka formulated. However, the provisions are yet to be incorporated in national legislation. Sri Lanka has yet to sign the ILO Conventions on Discrimination in respect of Occupations and Employment; on Migrant Workers; and on Home-based Workers.

Unequal wages for work of equal value in manual labour was eliminated in 1984 in 17 occupations, including tea and rubber in the plantation sector, under the Wages Ordinance Board.

[70] Schneider, F., Buehn, A. And Montenegro, C. 2011. 'Shadow economies all over the world'. World Bank Research Working Paper 5356.

Sri Lanka has signed and ratified ILO Convention 138 on the Minimum Age for Employment and C182 on the Worst Forms of Child Labour. In Sri Lanka, the law defines children as beings below the age of 18 years, and stipulates that all children must attend school until they reach the age of 14 years. Thereafter they are conditionally eligible to enter the labour market. However serious issues exist with regard to the gap between 14 years and 18 years, during which many children enter the hazardous labour sector, the effects of which can be harmful to their health, morals and safety.

In Sri Lankaȇs formal sectors, the following laws prohibit and or regulate the employment of children. The National Child Protection Act No. 50 of 1998, states in Article 39, that a child means any person under 18 years of age. The Constitution of Sri Lanka (1978) by Article 12 - Rights to equality; under Article 12(4) states no law can be made to prevent the advancement of women, children or disabled persons. The Employment of Women, Young Persons and ChildrenȏAct (EWYPC) is the main law pertaining to work by children.

The informal or unorganized sector with its substantial number of women workers in agriculture, industries and services is outside the ambit of legislation, which is an important point for coir fibre mills and coconut plantations that largely fall into the informal category. There is no clarity in the labour legislation regarding the minimum age of employment and the prohibition of employment under 12 years does not apply to the agricultural and urban informal sectors and to domestic service.

Other laws are of relevance to the current study are: Estate Labour (Indian) Ordinance, Factories Ordinance, Mines and Minerals Law and the Shop and Office EmployeesȏAct.

All occupational safety and health issues are legislated in Sri Lanka under the Factories Ordinance 1950 and subsequent amendments in 1976, 1998, 2000 and 2000. These are extensive and again only cover the formal sector. Specifically Part V addresses areas where most affecting fibre mills and pith factories

- The removal of dust fumes
- The protection of eyes
- Lifting of excess weights
- The prevention of noise and the protection of workers through the provision of suitable ear defenders

The following Sri Lankan environmental acts and regulations currently protect the natural environment in Sri Lanka.

The natural environment of Sri Lanka is protected through three key acts:

National Environmental Act No. 47 of 1980
National Environmental (Amendment) Act, No. 56 of 1988 and
National Environmental Act, No.53 of 2000.

The formal sector is routinely inspected and fines or closure are a penalty of non-compliance. During the on-site visits to pith factories there was plenty of evidence to suggest that this is an effective process promoting continual improvement in the formal sector.

As with labour laws, the environmental acts are not embedded in the informal sector. Much of the supply chain upstream of the pith processor falls in to this category and so coir fibre mills are generally not regulated.

A1.2. Environmental and labour legislation in India

India's Labour Policy is mainly based on Labour Laws. The World Bank reports that India has achieved impressive growth rates but retains high levels of inequality. The World Bank considers Indian labour laws among the most restrictive and complex in the world and one of the greatest challenges of doing business in India. According to the Bank these laws (including retrenchment) create not only inefficiencies but also massive inequality and may even facilitate caste bias in hiring.

The labour laws in the formal sector are as follows:

Factory Act (1948) and Delhi Factory Rules 1950

Minimum Wages Act 1948

Payment of Wages Act 1936

Payment of Bonus Act 1965

Employee Provident Fund and Miscellaneous Provisions Act (1952)

Industrial Employment Standing Orders Act (1946)

Employees State Insurance Corporation Act (1948)

Industrial Disputes Act (1947)

Bonded Labour System (Abolition Act 1976)

Child Labour (Prohibition and Regulation Act) 1986

Equal Renumeration Act (1976)

Maternity Benefit Act (1961) and

Trades Union Act (1926)

Although these laws may well be enforced in the formal sector there is a high level of informality in the agricultural sector – where in practice employees are not covered. There is a separate legislation which covers plantation labour, and since plantations are generally large, enforcement of labour laws is higher.

India's environmental control falls under the Environment Protection Act, 1986. Under this there are seven pollution regulations as follows:

- The Water (Prevention & Control of Pollution) Act, 1974, and its amendments
- The Water (Prevention & Control of Pollution) Cess Act, 1974 and its amendments
- The Air (Prevention & Control of Pollution) Act, 1981 and its amendments
- The Environment (Prevention) Act, 1986 and its amendments, (a) National Environmental Tribunal Act of 1995 and (b) National Environmental Appellate

Authority Act of 1997

- Hazardous Waste (Management and Handling) Rules, July 1989 and
- The Public Liability Insurance Act, 1991.

As with Indian labour acts and laws they are generally embedded in the formal sector but not the informal sector.