Asia and the Pacific Forest Products Workshop

Green Technology for Climate Change Mitigation and Adaptation

Editor
Sim Heok-Choh

Extended Abstracts
From the workshop held in
Colombo, Sri Lanka
14-16 December 2009

Jointly organized by:
International Union of Forest Research Organizations (IUFRO)
Forest Department Sri Lanka
Forest Research Institute Malaysia (FRIM)
Korea Forest Research Institute (KFRI)
Asia Pacific Association of Forestry Research Institutions (APAFRI)

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Green Technology for Climate Change Mitigation and Adaptation

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2. I-beams from panel products – look flimsy but strong – Jegatheswaran Ratnasingam

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INTRODUCTION AND WORKSHOP REPORT

Background

Climate change is a global problem, with global causes and effects. Climate change affects the basic elements of life for people around the world – access to water, food production, health, and the environment. Hundreds of millions of people will potentially suffer from hunger, water shortages, and more frequent severe natural disasters such as droughts, typhoons and floods, as the climate changes. Addressing climate change and dealing with the impacts requires urgent efforts by all.

The recently intensified debates and discussions on climate change in many international fora have introduced many additional challenges in the efficient and sustainable utilization of forest products. Efficient processing technologies and full (maximized) wood utilization constitute major components in the *green* business strategy designed to conserve resources, reduce impacts to the environment and human safety and health, and promote greater overall efficiency. On the other hand, alternatives, using bio-fibre waste or by-product of other industries, are continuously being sought to reduce dependence on non-renewable natural resources besides alleviating environmental impacts. The ultimate objective is to improve carbon reduction, carbon sequestration and carbon conservation leading to overall carbon emission reduction for climate change mitigation and adaptation.

Several nations, over the past decade, have initiated various mitigation and adaption measures to cope with future climatic conditions. Theories and technologies have being proposed, discussed and implemented to meet these challenges for climate change adaptation and mitigation. While many of these technologies and products have been well researched and documented, many factors have hindered the adoption by the industries. Overcoming such hindrances will require commitments and responsibilities to invest in capacity and capability building.

The workshop

The main objective of the workshop was to provide a forum for linking various international, regional and national agencies and institutions dealing with climate change issues in forest products processing and utilization, and to share strategies, experiences and knowledge, related to green forest products technology. This workshop provided the much needed opportunities for individuals and their associated agencies, organizations and networks to build collaborative linkages and better align programmes to capture synergies. Various organizations, including IUFRO, were able to take this opportunity to assess capacity-building needs in terms of research and extension related to green forest products research, development and utilization in the Asia-Pacific region.

The workshop was an initiative of the International Union of Forest Research Organization (IUFRO). It was funded by an allocation from the contributions of the Korean Government, through the Korea Forest Research Institute (KFRI), to IUFRO. The Asia Pacific Association of Forest Research Institutions (APAFRI) organized the three-day workshop, in technical collaboration with the Sri Lanka Forest Department, Forest Research Institute Malaysia (FRIM), and the Korea Forest Research Institute (KFRI). The workshop held at the Club Palmbay, Marawila, Sri Lanka attracted 35 participants from 11 countries across the Asia-Pacific region. A total of 22 papers were presented in three technical sessions. A one-day field trip gave the participants the opportunities of visiting a wood handicraft workshop, a rattan furniture factory and a rubberwood bloom and brush handles factory. The participants also visited the Elephant Sanctuary and the capital city, Colombo.

Panel Discussion

Dr Dave Cown, a senior scientist of Scion, New Zealand; and also the Coordinator of Division V, IUFRO; facilitated a panel discussion on the afternoon before closing. The panelists: Dr Hiran Amarasekara (Sri Lanka), Dr GS Rawat (India), Dr Jegatheswaran Ratnasingam (Malaysia) and Dr Arsenio Ella (Philippines) started the discussion sharing their views and thoughts on the subject matters. Several participants responded with their own views and experiences.

Climate change is causing tremendous damages in many countries. Recent typhoons, with increased severity and frequency, have been attributed to climate change. People are blaming the felling of trees in illegal logging activities. Tapping of resins has been banned in the Philippines, as some postulated that this would contribute to damaging the trees and lead to forest fires adding to environmental pollution. However, one should recognize that climate change is inevitable and unavoidable. The impacts are very clear as evident in many countries.

Science shall be able to play an important role in mitigation and adaptation to climate change, although many hold that currently climate change issues have largely been political debates, rather than science. Discussions should be compiled to generate sufficient awareness and contribute to policy formulation on what and how we could move forward. The scientific community should be aware of all these and contribute in whatever manner to climate change mitigation and adaptation. Strategy should be developed, for example, using more of the alternative species or products to reduce dependence on natural forests. Climate change mitigation and adaptation should be given priority in formulating research strategies. International competitiveness should be also an important aspect when one talks about ‘green’ products and processes.

Most of the developing countries would think that adaptation to climate change is more important than mitigation. Issues on climate change should begin with raising the awareness. For example, in energy issues, many are unaware of the impacts of scientific information. This information ignorance and to a certain extend, knowledge gap have generated myth more than facts. For example, while many have promoted planting jatropha for bioenergy production, some had in fact proved that it is a non-economical option. Public awareness in climate change mitigation and adaptation, to achieve sustainable life style is rather weak. Many are not aware, and are not prepared to change their life style to adapt to climate change. Information and knowledge sharing and exchange through various means such as dissemination using printed and digital media; through training workshops, conferences, and industrial visits; would be essential in closing these gaps and achieve better success.

Awareness through the proper media should surely guide towards the right actions. Awareness and accessibility to information should be for all levels and all social strata. More environmentally friendly products, including ‘green’ buildings, which are energy efficient, produced by ‘green’ technologies, would need to be developed and promoted. In addition it is the people that would need to be convinced to adopt the proposed strategies and policies for action. Transferring science to applications require some concerted efforts. Local conditions do not necessitate the adoption/adaptation of ‘green’ technology/products. Incentives and/or government commitments perhaps would help. Research must be scientifically sound and results be disseminated to the right audience and stakeholders. The apparent benefits to be gained would be a strong push factor for adoption of new technologies or products. Government imposed regulations usually means additional costs, and unless and until the benefits can be shown to outweigh the costs, adopting such new technologies and products would be difficult.

Prices of wood products are still cheap. Climate change mitigation and adaptation is a good opportunity to raise the awareness that wood products should demand higher prices. Life Cycle Analysis and assessment of carbon footprints would be good tools to provide the justification to support higher prices for wood products. However, many baseline data are still lacking, however.

In many of the Asian and pacific countries, the small and medium enterprises (SME) are always reluctant to be certified, as there is lack of government support. Certification should be viewed as supportive, rather than a barrier.

Resource information for NWFP (NTFP) is generally lacking or inadequate to promote fuller utilization of such resources. Nevertheless, domestication and plantation development of NTFP have lots of potential in many countries.

Wood products and forestry experts are not influencing policy formulation in many of the Asian and Pacific countries. More often than not, scientists are not involved or consulted in strategic planning or policy formulation. Furthermore, in the forest products industries, the industrial associations typically have different views and different expectations. These have further complicated and hindered effective contribution to shaping strategy and policy. Without the significant participation and consultations with all the stakeholders, especially the research and industrial communities, most of the problems faced would remain unresolved as the policy implementation would prove to be ineffective. A statement, capturing the overall outputs of this workshop could be forwarded to IUFRO, FAO, or other relevant international agencies. By so doing, more attention could be attracted to the impacts and issues related to forest products and the associated industries.

Opening Address for the Asia and Pacific Forest Products Workshop on Green Technology for Climate Change Mitigation and Adaptation

KIM WaeJung
Assistant Director General
Korea Forest Research Institute

Good Morning!
Ladies and Gentlemen

On behalf of Government of Republic of Korea, and Korea Forest Research Institute, it is indeed my pleasure to welcome all participants to Sri Lanka, particularly in this beautiful City Marawila. My heartfelt thanks are also extending to Dr. Sim Heok-Choh Executive Secretary General of the Asia and the Pacific Association of Forestry Research Institutions (APAFRI) and the Sri Lanka Forest Department for their support to host this Workshop.

Upon UN Climate Change Conference (COP15) Copenhagen, worldwide 56 newspapers in 44 countries took one voice through a common editorial that "Climate Change affects everyone, and must be solved by everyone, and kicking our carbon habit within a few short decades will require a feat of engineering and innovation". The coming carbon race with green technology must be driven by a collaborative effort to achieve collective salvation. Recently, the Presidential Committee on Green Growth of Korea, decided 4 percent cut in greenhouse gas emissions by 2020 from 2005 levels. In order to hit the harsh target, renewable resources of bioenergy will share as high as 3% of total energy consumption of Korea by 2030.

The trees in a forest can absorb large amount of CO_2 and store it as wood. Each cubic meter of wood contains about 250kg of carbon dioxide which corresponds to the emission of a middle class family car driving 73,000 km or 1.66 times around the earth. According to recent estimates, the average life of wood products varies between 2 months for newspapers and 75 years for structural wood. So increasing and longer the use of wood is one simple way of reducing climate change.

In other words, we can tackle Climate Change by using a greater proportion of wood products, with a longer life, recycling and substituting wood and wood-based products for concrete, aluminium and steel. Since biofuel provides a carbon neutral substitute for fossil fuels, wood combustion does not contribute to global warming or green gas effect. Wood fuel is clean since it contains little of the sulfur or nitrogen causing acid rain.

Ladies and Gentlemen

I hope that this workshop gives you many opportunities for a better understanding of environmental, economical and social benefits to be gained by wider and wiser use of wood and wood-based products. Also this workshop provides all participants to share experiences and knowledge related to green technologies and green business in forest products industry.

Before my closing, I welcome you all to the 23rd International Union of Forest Research Organizations (IUFRO) World Congress in Seoul in 2010. I believe that the Congress will offer various topics and interests of forest science and technology under the main theme " Forest for the Future: Sustaining Society and the Environment"

Once again, I sincerely hope you all may have fruitful and joyful experiences in Sri Lanka during your stay.

Thank you.

Opening Address for the Asia and Pacific Forest Products Workshop on Green Technology for Climate Change Mitigation and Adaptation

Abd Latif Mohmod
Director General, Forest Research Institute of Malaysia
Chairman, Asia Pacific Association of Forestry Research Institutions

Good morning, Ladies and Gentlemen

On behalf of APAFRI, I would like to welcome all of you to this Asia Pacific Forest Products workshop with the theme: Green Technologies and Products for Climate Change Mitigation and Adaptation, here in Sri Lanka.

I would like to thank the Forest Department, Sri Lanka, for hosting this workshop here. Many of you are aware that the fund for organizing this workshop is a portion of the Korean Government's contributions to the International Union of Forest Research Organizations (IUFRO). Since 2007, the Korean Government, through the Korea Forest Research Institute (KFRI), has allocated a portion of its contributions to IUFRO for activities to be carried out in the Asia Pacific region for forestry practitioners of this region. APAFRI is honoured to be entrusted with the responsibilities of managing this portion of the fund. APAFRI has used the 2007 allocation for partially financed the International Conference on Traditional Forest-related Knowledge in Kunming China, and the 2008 allocation for organizing an Asia Pacific Forest Health Workshop in Kuala Lumpur. Proceedings for these two events have already been published by IUFRO as IUFRO World Series Volume 21 and Volume 24.

Ladies and Gentlemen

Allow me to take this opportunity to briefly introduce APAFRI. APAFRI stands for Asia Pacific Association of Forestry Research Institutions. APAFRI's role is to act as a catalyst, facilitator, and information hub for research and conservation activities in the Asia Pacific. APAFRI aims to promote and assist in the development of the region's scientific research and development culture and capacity and to foster the establishment of institutional and professional collaborations among the region's forestry researchers. APAFRI's activities support sustainable management and utilization of forest resources at the local, national and regional levels. As of December last year, APAFRI's membership stands at 64 forestry research institutions, and 8 individual members. Most of the national research institutions and many universities in the region from Korea to Pakistan, and from China to Australia are members of our Association. I recognized many of the participants present here today, who are also staff members of active member institutions in APAFRI.

The establishment of APAFRI was promoted by the need to provide a viable institutional framework for research collaboration in the region. APAFRI was formally launched in Bogor, Indonesia in 1995 during a regional meeting of heads of forestry research organizations in the Asia Pacific. We have the Fifth General Assembly just two months ago, which has elected a new Executive Committee, chair by me, that would manage APAFRI activities for the next three years.

APAFRI is continuously looking for opportunities to jointly develop programmes and services for its membership and alliances. We would like to seek more cooperation and collaboration from you all, members and non-members, to assist us in servicing the forestry sector in the Asia Pacific Region better in future.

I wish you all have a fruitful meeting here in this beautiful seaside resort.

Thank you.

Opening Address for the Asia and Pacific Forest Products Workshop on Green Technology for Climate Change Mitigation and Adaptation

Sarath Fernando
Conservator General of Forests, Sri Lanka Forest Department

Dr. Abdul Latif DG FRIM and Chairman of APAFRI, Dr. G.S. Rawat DG Indian Council for Forestry Research and Education and Vice Chairman APAFRI Dr. Dave Cowan Senior Scientist wood quality coordinator, IUFRO Division 5 (Forest Products) Dr. Sim Executive Secretary, APAFRI, distinguished participants from foreign countries and Sri Lanka, distinguished invitees, Ladies and Gentlemen.

First of all let me welcome you all to this workshop.

It is a great honor for me to address this gathering where issues and strategies of green technology for climate change mitigation and adaptation will be discussed. Timing of this workshop is appropriate as the climate change conference of UNFCC is taking place in Copenhagen, Denmark at this moment. It is estimated that tropical deforestation and forest degradation contributes to about 20% of Co_2 emission. It is unfortunate that forestry sector was not given its due consideration in climate change strategies in the past, although forests, could contribute to mitigation and adaptation aspects of climate change, However I hope that this will be changed during the UNFCC Meeting in Copenhagen, Denmark when the strategies of reduction of emission from deforestation and forest degradation (REDD or REDD +) will be discussed and maybe accepted.

Distinguished Delegates, Ladies and Gentlemen,

The way we manage and use our land and the way a changing environment affects our natural resources are directly linked to both sides of this question. Forests and forest products can play a significant role in mitigation of harmful effects of green house gas emissions. They can act as a “sink” to absorb emissions and store large quantities of carbon for extended periods of time. Forests are also an important component of adaptation strategies needed to address continuing, sometimes dramatic, changes in the natural resource base that sustains our livelihoods. Sustainable forest management is thus a critical component of any policy and action programme that seeks to address the growing global concern about the impacts of climate change.

Of course, forests provide a wide range of benefits beyond those related to climate change. Accounting for approximately thirty percent of the world’s land mass, forests provide economic, social, cultural and environmental services. More than one billion people live in or around forests and use forest resources for fuel, timber, food, medicine and income; of these, 70 million are Indigenous Peoples living in remote areas that depend completely on forest resources for their livelihoods. In addition, forests contribute significantly to populations living farther a field through the provision of a wide range of forest products, recreational opportunities as well as environmental services such as protection of the watershed. Clearly, the potential contribution of forests to the mitigation of climate change is just one of many benefits forests provide for local communities and urban populations, as well as for large number of business enterprises.

Forests store large amounts of carbon in trees, under-story vegetation, and soil. It is estimated that, they contain some 1.2 trillion tones of carbon, just over half the total in all terrestrial vegetation and soils. Generally speaking, young, growing and well managed forests are good “sinks”. Not all forests are good carbon “sinks”. Old-growth forests may be net-emitters of carbon as the large proportion of older trees begin to decompose. Nevertheless, human activity in the form of deforestation and forest degradation are the primary drivers of carbon emissions from forests. Forest management and forest operations have a long term effect on human-generated emissions, and all the factors contributing to the balance between emissions and storage are not yet fully understood.

The causes of deforestation and forest degradation are complex and are often manifestations of careless extraction of natural resources without proper management and regeneration activities. Thus sustainable forest management provides a method of balancing diverging priorities of sustainable economic and social development on the one hand, and ecological sustainability on the other.

Deforestation and forest degradation are the result of a confluence of actors, interests and circumstances. Drivers range from the growing demand of timber and forest products in global markets to conversion of forest land to pasture for large scale cattle ranging or more profitable agricultural products, such as corn or palm oil. Forest land is also sacrificed to meet the needs of local communities for land to use in subsistence agriculture. A diverse set of changes such as in technology, access to roads and transport, prices of agricultural inputs, industrial development and fluctuating labour markets at the local and national levels - to name a few - can have both positive and negative impacts on the rate of deforestation.

The issue of forests and sustainable forest management has been a priority on the international policy and political agendas dating back to the 1992 United Nations Conference on Environment and Development (UNCED). The non legally binding instruments of UNFF provide countries with a number of policy proposals intended to guide and assist the implementation of sustainable forest management. These include guidance on issues such as:

- Forest Law Enforcement and Governance
- International Trade in Forest Products
- Protection of Forests
- Science and Research
- Public Awareness and Education
- Private Sector and Industry
- Indigenous and Local Communities
- Monitoring, Assessment and Reporting

Sustainable forest management contributes significantly to mitigation of harmful effects of greenhouse gasses. In general, the term mitigation refers to all activities aimed at reducing green house gas emissions and / or removal of CO2 from the atmosphere with the aim of stabilizing CO2 concentrations.

One of the actions among several which is undertaken in the forestry sector which can be used effectively for this purpose is, Increasing the use of forest-based products such as bio-energy and durable wood products, and substituting these for less eco-efficient materials. Efficient utilization of forest products, especially wood, which has carbon as its main element, offers significant opportunities to reduce carbon in the air and thereby contribute to climate change mitigation.

Green technology is the future of this society. It's main goal is to find ways to produce technology in ways that do not damage or deplete the Earth's natural resources. In addition to not depleting natural resources, green technology is meant as an alternative source of technology that reduces fossil fuels and demonstrates less damage to human, animal, and plant health, as well as damage to the world, in general. Next, green technology is so that products can be re- used and recycled. The use of green technology (clean technology) is supposed to reduce the amount of waste and pollution that is created during production and consumption.

There is a growing awareness of the need for an efficient processing technology and maximized wood utilization. This constitutes a major component in the *green* business strategy designed to conserve resources, reduce impacts to the environment and human safety and health, and promote greater overall efficiency. These would involve improving production techniques and technologies; including substituting different materials and energy sources, modifying equipment and redesigning products. The ultimate objective is to improve carbon reduction, carbon sequestration and carbon conservation leading to overall carbon emission reduction for climate change mitigation and adaptation. In addition to environmental, health and safety benefits, many green technologies can provide opportunities for positive financial returns.

The main objective of this workshop is to provide a forum for linking various international, regional and national agencies and institutions dealing with climate change issues in forest products processing and utilization, and to share strategies, experiences and knowledge, related to green forest products technology. The workshop will provide an opportunity for individuals and their associated agencies, organizations and networks to build collaborative linkages and better align programme to capture synergies. The workshop will also provide an opportunity for various organizations including IUFRO, to assess capacity-building needs in terms of research and extension related to green forest products research, development and utilization in the Asia-Pacific region.

I thank APAFRI and KFRI for accepting my proposal to hold this workshop in Sri Lanka.

Finally I wish that you will have very fruitful deliberations on the subject and come up with effective recommendations which could be used to formulate strategies to mitigate some of the impacts of climate change and also to formulate appropriate strategies for adaptation.

I also wish you a very pleasant stay in Sri Lanka.

GREEN TECHNOLOGY FOR CLIMATE CHANGE MITIGATION AND ADAPTION

Dave Cown
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Forests and forest products perform three major functions, which could potentially mitigate the continuing increase in atmospheric carbon dioxide concentration and associated climate change:

1. Produce and store carbon, absorbing atmospheric carbon dioxide.
2. Allow harvested wood products (HWP) to store carbon after the forests are felled and utilised.
3. Permit conservation of fossil fuels by replacing more energy-intensive products and provide a sustainable source of bioenergy.

Forests also provide important environmental services including erosion control, water quality improvement and recreation, which contributing to climate mitigation and adaptation too. Furthermore, a wide variety of forest products are used by local communities for food and medicinal purposes.

The continuing global loss of forests is a major concern to governments worldwide. Deforestation contributes 18% of green house gas emissions. The inexorable increase in word population, together with shifting climatic patterns, will put more pressure on the land to sustain local communities which rely on forest products of various kinds. In more highly developed societies the pressures are somewhat different and tend more towards energy production and recreation requirements (Aulisi *et al.* 2008).

There are now some signs of positive progress as indicated in recent FAO reports. The reduction in deforestation levels and the continued increase in planted and managed forests (FAO 2005) is a double benefit in that it will increase the average yield from managed forests while relieving the pressure on native forests and allow them to better provide food and shelter security for those reliant on their production. However, the uneven regional progress towards sustainable forest management suggested by the 2007 State of the World's Forests (FAO 2009) is a clear sign of where the future emphasis needs to be put.

The huge global trade in forest products has developed over many centuries, and has developed to meet the wood demands of countries with insufficient natural resources. The nature of the actual products themselves varies regionally will continue to change as material increasingly comes from planted and managed forests. Biomass as a raw material will increase in demand as a substitute for energy-hungry alternatives, so there will be challenges in expanding the ability of forests to meet the needs of societies worldwide (EIA 2009). Biomass will become the material of choice for a much broader range of uses in future (Ahmad 2006, Hall and Jack 2008).

Apart from the immediate needs of local populations, forests and forest products contribute substantially to the mitigation of climate change by acting as carbon sinks and protecting the value of the land. For example, substituting 1 cu m of wood for other construction materials saves about 1 tonne of carbon dioxide emissions. Metallic products emit five times more carbon dioxide than wood products during their life cycles. There is however a big job to be done to convince the general public and policy makers of the environmental benefits of wood products.

The whole wood processing sector is examining ways increasing efficiency by improving conversion efficiency, reducing energy requirements, and substituting renewable products into buildings. Some of these which have been successfully implemented by the forestry industries include: log scanning and allocation, small log utilization, thin kerf sawing, board grade scanning and optimization, rapid drying, defecting and finger-jointing, and wood-waste for energy. While many of these innovative technologies are important for industry profitability, their contributions are only marginal on a global scale.

Increasingly, wood or biomass in general, has been used to supplement the fossil fuel in energy generation. Biomass is fundamentally different from fossil fuels because it only recycles carbon into the atmosphere whereas fossil fuels introduce new carbon. Apart from using small logs, residues from forest harvesting and wood products manufacturing, woody crops are being grown in short rotation plantations for heat and electricity generation. Wood plantations, besides rehabilitating lands and provide environmental services, are renewable, energy efficient (solar driven) and highly productive. Although a number of agricultural crops such as corn and sugarcane are also used to produce ethanol or diesel additives (biodiesel), wood (both hardwood and softwood) has higher yield than all these other crops.

Improving the sustainability and profitability of forestry and forest products industries would remain a major research challenge. New products, typically from biomass, would need to be developed to replace energy intensive traditional products. The greatest challenge will be to translate the scientific knowledge of the benefits of forests and renewable wood products into local actions so that governments and legislators are put in the position of having to act in favour of sustainable forest management and environmentally-sound utilisation.

There is a big job to be done to convince the general public and policy makers of the environmental benefits of forests and wood products.

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BIOFUEL – A GREEN ENERGY OPTION FOR MITIGATING HUMANITARIAN CRISIS OF CLIMATE CHANGE

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Background

The 'Green Energy' is an innovative approach where biofuel crops are integrated into the land-based livelihood systems to provide energy solutions. It is also an ecosystem instrument with carbon sequestration capacity. The innovations in biofuel and climate change mitigation and adaptation are connected through two strings; one is related with the expected changes in the land- the biosphere; the other is their climate change mitigation effects. The possible contributions of green energy in addressing the detrimental effects of climate change and the increasing humanitarian crisis provide a promising basis to work with. The most vulnerable sectors to the climate change are the poor and the subsistence farmers. They are to be prepared with alternative sources of livelihood with multiple options to deal with the humanitarian crisis. This situation demands anthropogenic measures for reducing the short term repercussions and mitigating them in the long term.

In Sri Lanka two models: the plantation models and small scale farm models, are being introduced at various locations. These have generated an overwhelming interest due to the pressing need for securing local solutions to the energy crisis and possibility for reducing the dependency on imported fossil fuels. Interventions also spurred a strong debate over possible implications on food production, land rights, poverty etc. This paper presents the lessons learned by carrying out research on biofuel development initiatives made by introducing *Jatropha carcus* into small scale farms in the dry zone of Sri Lanka. Sri Lanka has tremendous green development opportunities and a population sourced by the land-based livelihood. According to the estimations made by the University of Wisconsin, Madison in 2007, Sri Lanka has high economic potentials for processing biofuel.

The Green Energy development offers multiple windows to reduce the gravity of humanitarian crisis of climate change while building resilience. To turn this offer into a reality possibility for accommodating biofuel crops into the unutilized or underutilized lands should be carefully examined involving the communities through their traditional multiple resource management systems. Country has to explore the full potentials of 'the green energy', through 'farm-forestry' interventions drawing attention to the satisfactory results derived by growing, processing and oil extraction, and a wide range of end-use potentials of *Jatropha* and many varieties of species with oil producing potentials.

The Green Energy Innovations

The green-energy innovations are to be combined with reforestation and afforestation strategies and utilize the low productive lands of the small scale farmers through farm forestry and agro-forestry models in the dry zone of Sri Lanka. J*atropha* which is known as 'weta-endaru' or 'wal-endaru' is a widespread and well known drought resistant, perennial species with a lifespan extending over a period of 50 years or so. Its potentials as an 'energy crop' are not known to the farmers. The process has been started as a community-based innovation with hedgerow cultivation in Leekolapitiya, Nikaweratiya; and also experiment as a monoculture crop in various locations. In Leekolapitiya the hedgerow cultivations are the 'feedstock producing reserves' for a community-based processing centre. A civil society organization of the small-scale farmers, undertook the responsibility of supplying seeds and growing *Jatropha* to sustain the supply chain.

A Solution to Humanitarian Crisis

The contribution of this 'green energy' innovation to addressing the humanitarian crisis of climate change which has become a pressing problem for the local farmers is central to local adaptation. The analysis carried out by the author involving the community in Leekolapitya reveals that the implications of the green energy innovations on climate change mitigation and adaptations are not known to the people, but awareness on multiple benefits creates the motivation mobilize resources. The areas requiring emphasis are interrelated. First is the reforestation or re-greening of the lands that had suffered from various external causes: the climate change calamities, including the extended droughts and the events of flash floods. Second is the positive effect of green crop cover in reducing direct soil moisture evaporation, and diverting the water through the process of transpiration assuring the oil crop -*Jatropha* production. The third is associated with the effects on soil development and controlling surface runoff and erosion, enhancing carbon and water cycles. The fourth is the effects on enhancing carbon sequestration, carbon storage potentials and reducing GHG emissions. The fifth is contributions to livelihood diversification, poverty reduction, and gender equity through which the land-based development could benefit sustainably the farmers, farm women in particular, by generating employment and cash income.

Moving Beyond Cost of Production

The economic viability of biofuel production is a seriously concern. The production cost of a litre of *Jatropha* oil is around US$1.40, and a litre of biodiesel is around US$2.00. It is expected that the cost of production could be reduced substantially when the scale of operation is expanded and if improved seed varieties are introduced. There is a challenging demand for including new variables related to climate change mitigation aspects into the assessment, rather than considering them as spill-overs of the green energy interventions. The potential contributions for enhancing carbon sequestration, reducing carbon emission, and also increasing the productivity of agro-ecosystems through soil and water conservation could strengthen the stakeholder partnership and commitment. According to the farmers, the cultivations contribute to reduce the soil moisture evaporation loses and sustain relatively cool conditions. *Jatropha* also could serve as a shade crop or a nurse crop for the food crops. The challenge is to develop models suitable for the abandoned lands and the lands that are cultivated only during the rainy season. Intercropping, which is in practice in the area is a suitable model. A fixed spacing model does not suit all the lands that farmers are willing to allocate for growing *Jatropha* either as a monoculture crop or for intercropping the underutilized lands. The farmers prefer to grow several rows of *Jatropha* in seasonally fallowed fields to secure a supplementary source of income. Such income is essential to reduce the losses of occasional crop failures and also to maintain a green cover. Multiple options are requested for the lands that are not cultivated and 60% of the farmers prefer to have various biofuel species that allow them to develop several canopy layers; for example with *neem* in the upper-canopy and *Jatropha* in the mid-canopy.

The analysis of green energy innovations shows that they are capable of contributing to livelihood security and help address humanitarian crisis of climate change, and the crisis of energy security. The advantages of *Jatropha* are to be fully explored focusing on the phenological cycle as well as the long-term lifespan effects on the environment. Preliminary analysis reveals four key points. The first is the possibility of coppicing the plants for rejuvenating the growth and thereby a good harvest of oil-bearing seeds. The second is the easy establishment through vegetative propagation. The third is the contribution to carbon cycle and soil improvement because the amount of biomass removed is extremely low compared to the leaf litter and the canopy cover. The fourth is the possibility to sustain the system through sustainable resource management practices without chemical inputs. The architecture of the plants is extremely favorable for maintaining a high leaf area which is crucial for mitigating the climate change effects and increasing the capacity of the lands to stand against extreme weather conditions. In addition the local applications of biofuel; oil for lamps, mechanization of water pumping and cooking are to be taken into account from the perspectives of reducing fossil fuel consumption and reducing carbon emissions.

The Findings

Biofuel crops create land-based livelihood options/enterprises responding to the emerging climate change repercussions. The local utilization of biofuel helps reduce consumption of fossil fuel and reduce GHG emission, while carbon sequestration into the system and storing potentials provide clearing out effects. The transitions cannot be expected from energy interventions alone, and for better results the forestry and agriculture should be involved in introducing best farm forestry and agro-forestry models. Strong social capital/civil society organizations are needed for the sustainable management of resources, supporting a production chain with a sub-contracting system for the sustainable feed-stock supply and benefit sharing. A favorable policy framework is needed to create awareness on the contribution to address humanitarian crisis of climate change, and to mobilize resources and local interest.

Three compatible approaches for climate change mitigation can be adopted. The first is a ‘gender inclusive approach’ enabling men and women to accommodate mitigation measures to their livelihood system and build resilience to the deepening crises. The second is a ‘package approach’ advocating for integrating climate change, livelihood diversification, energy and the environmental sustainability. The third is a ‘human security approach’ through which cooperation for climate change mitigation and habitat security could be built up for mobilizing capital, locally, regionally and globally. Willingness to pay for the additional benefits of green energy and the clearing out effects on the atmosphere need favorable energy policies.

STATUS OF GREEN-MANUFACTURING PRACTICES AMONG SOUTH EAST ASIAN WOODEN FURNITURE MANUFACTURERS

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Introduction

In recent years, environmental concerns have been growing against the background of the increasingly strong evidence for global climatic change. Societies throughout the world are increasingly concern about human activities that could affect the future of the planet, particularly those related to deforestation and use of unsustainable natural resources. Of late, the wood products industry has gained international attention for its 'green status', despite being an important socioeconomic sector in many developing countries throughout the world. Despite being environmental-friendly, the manufacture of wood products has often been regarded as being wasteful and harmful to the environment through its emission of dust and other pollutants. The 3D (dirty, dangerous and degradatory) stigma associated with the working environment in the wood products industry has emerged even more prevalent in recent years. With the growing environment concerns of the wood products industry throughout the world, the wooden furniture industry is being scrutinized for its environmental friendliness, as it has emerged as the fastest growing sub-sector within the wood products industry in many parts of the world. However, information on the status of environmental friendly practices within the wooden furniture industry is sparse (Ratnasingam *et al.* 2009). Further, most available reports do not separate the wood products industry into the various sub-sectors, and hence, the assessment of the environmental-friendly status has been rather skewed, undermining the accuracy of the report, with particular reference to the wooden furniture industry. Therefore, a regional survey of green manufacturing practices and the adoption of the ISO 14001 environmental management system was undertaken to provide an insight into these issues, and to identify approaches that could be implemented to improve the environmental status of the wooden furniture industry.

Methodology

The study was implemented through a survey of 350 wooden furniture manufacturers in the South East Asian region, involving Malaysia, Indonesia, Philippines, Vietnam and Thailand (Table 1). These manufacturers were medium to large in size, defined by their workforce exceeding 100 and with a turnover of more than US$ 5 million per annum. The questionnaire-based survey was sent to the selected companies, through their respective national furniture trade organizations, after obtaining their consent to participate in the survey. The questionnaire had two parts, i.e. Part I evaluated the current green manufacturing practices in the companies, while Part II assessed the level of adoption of the ISO 14001 environmental management system in the companies. Part I consisted of 15 statements, and the respondents had to indicate their degree of agreement on the basis of the 3-points scale (1 = agree, 2 = disagree, 3 = not relevant). Part II had 10 statements, to which the respondents had to state their degree of agreement on the basis of the 5-points Likert scale (1 = very true, 2 = true, 3 = acceptable, 4 = not true, 5 = not true at all). The questionnaire was developed after extensive consultations with industrial experts, and it was pre-tested at 25 factories in Malaysia, before it was sent out to the respective national furniture trade organizations for implementation. In order to ensure representativeness of the study, the total sample size in each country was kept at a minimum of 60 companies, while Malaysia and Thailand had 94 and 76 respondent companies, respectively.

Table 1. Characteristics of the Respondents in the Survey

Countries	Number of Respondents	Export Oriented	Domestic Market Oriented
Malaysia	*94*	*60*	*34*
Thailand	*76*	*39*	*37*
Vietnam	*60*	*50*	*10*
Indonesia	*60*	*44*	*16*
Philippines	*60*	*45*	*15*

Results and Discussion

The results of the survey revealed that the current green manufacturing practices in place within the wooden furniture industry in the South East Asian region was primarily focused on raw materials use, rather than process technologies. Table 2 shows that current green manufacturing practices in the wooden furniture industry, and it is apparent that furniture manufacturers in the region appear to be more adaptive in using environmental friendly materials which provides a short-term proposition, rather than investing into green processing technologies which provides a long-term proposition. Further, in terms of the adoption of green manufacturing practices, export-oriented companies were more receptive compared to the manufacturers catering for the domestic market. In terms of adopting green manufacturing practices, the industries in the various South East Asian countries vary significantly, with the levels of adoption following the trend: Malaysia > Philippines > Thailand > Vietnam > Indonesia. This could be attributed to the export/production ratio of wooden furniture in the respective countries, clearly suggesting that green manufacturing practices is a market-driven phenomenon rather than an industrial strategy (Ratnasingam *et al.* 2009).

Table 2. Current Green Manufacturing Practices among SEA Wooden Furniture Manufacturers

Green Practices	% Application of the Practice among Respondents
Certified Wood Resource	87
Low Formaldehyde Adhesive	84
Low Volatile Organic content (VOC) Coating	83
Recyable Fiber Packaging	69
Waste Reduction	69
Automated Machinery	43
Low Energy Heating System	40
Workers Training	43
Application of ICT	40
Optimization Techniques	32
In-Line Process Control Technologies	24
Water Based Coating	22

With respect to the adoption of the ISO 14001 environment management system, the survey revealed that only 23% of the respondents had adopted this system. Hence, the adoption of the ISO 14001 system among wooden furniture manufacturers in the South East Asian region is relatively low, but those who have adopted the system report significant cost savings, especially through the reduction in rework, rejections and energy cost (Table 3). The fact that the ISO 14001 environmental management system involves an initial investment cost which is considered as prohibitive by many of the respondents clearly suggests that cost is the prime driver behind the adoption of the system. Further, without any significantly higher price premiums on the 'green wooden furniture' serves as a disincentive to potential manufacturers who may be contemplating to adopt green manufacturing practices as a strategy to increase market-share. Studies have shown that in labour-intensive industries, such as wooden furniture manufacturing, cost drivers are the primary determinants in the adoption of any form of systems and manufacturing practices. Therefore, unless the value-proposition offered by such systems is obvious to the wooden furniture manufacturers, such systems may remain in the sidelines until the market forces dictate its adoption.

Table 3. Elements of ISO 14001 Adopted by Wooden Furniture Manufacturers

Work Elements	**% of Application among Respondents**
Waste Reduction	93
Less Rework	85
Lower Energy Cost	82
Lower Idle Time	79

Conclusions

On the account of these results from the regional survey conducted, it is apparent that the adoption of green manufacturing practices and the ISO 14001 environment management system are market-driven phenomenon. However, with increasing market-pressure and awareness among manufacturers of the benefits to be derived through the adoption of such practices, it is envisaged that green manufacturing practices is poised to grow in the future.

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ISSUES OF FORMALDEHYDE EMISSION FROM WOOD COMPOSITE PRODUCTS OF MALAYSIA

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Introduction

What is Formaldehyde?
It is an important industrial chemical used to manufacture other chemicals, building materials, and household products. It belongs to the large family of chemical compounds called volatile organic compounds or 'VOCs'. The term 'volatile' means that the compound can vaporize, that is, become a gas, at normal room temperatures.

Background

Uses of Formaldehyde
The uses of formaldehyde are in glue or adhesive manufacture for pressed wood products (particleboard (PB), medium density fibreboard (MDF), plywood); in preservatives of some paints, coatings, and cosmetics; in coatings that provides permanent press quality to fabrics and draperies; in finishes used to coat paper products; and in insulation materials (urea formaldehyde (UF) foam and fiberglass insulation).

Formaldehyde Emission
Formaldehyde is released into the air by burning wood, kerosene or natural gas, by automobiles, and by cigarettes. It is also emitted in small amounts from materials made with it.

Normal Levels of Formaldehyde
The normal level of formaldehyde is low, < 0.03 ppm, in both outdoor and indoor air with rural areas having lower concentrations. Residences or offices containing products that release formaldehyde to the air can have formaldehyde levels > 0.03 ppm. Products such as particleboard used as flooring underlayment, shelving, furniture and cabinets; MDF in cabinets and furniture; plywood wall panels and UF foam insulation give levels that vary with product depending on resins used.

What Affects Formaldehyde Levels?
The levels of formaldehyde in the indoor air depend on the source, temperature, humidity, and air exchange rate in the room. As the temperature in the room rises, more formaldehyde is emitted from the products in the room. More formaldehyde is released as the humidity rises. Increasing the flow of outdoor air to the inside decreases the formaldehyde levels. Some sources release more formaldehyde when new. As they age, the formaldehyde release decreases.

Formaldehyde Issues

Effects of Formaldehyde on Man and Animals
Formaldehyde affects people differently. Some people are very sensitive while others are not. Some have allergic reactions (allergic skin disease and hives) through skin or durable-press clothing containing formaldehyde. Others develop asthmatic reactions and skin rashes. It should be noted that formaldehyde is just one of several gases present indoors that may cause illnesses. Many of these gases, as well as colds and flu, cause similar symptoms. To date, no human has died from HCHO poisoning, only animals. The available epidemiological studies on man exposed to formaldehyde show no increase in overall rate in cancer or in individual cancers. The European Union, however, has placed formaldehyde under the C2 classification (probable carcinogen).

Formaldehyde issues in wood products
The issue of formaldehyde emission from wood products was sparked by the use of urea formaldehyde foams as insulation material in mobile homes. During hot summer conditions, occupants of these homes are known to get nausea very easily. The International Cancer Research Agency in the US has conducted a number of tests on mice and has concluded that formaldehyde is a suspect for causing cancer. It later found that formaldehyde can cause cancer in mice.

The timber industry in Malaysia contributes very significantly to the national economy. Being an export orientated industry, the revenue obtained in 2008 reached RM 22.79 billion, the 4th largest export of primary commodity. Wood-based panels and wood furniture account for 61% of the export value.

a. *Export to Japan*

Japan is Malaysia's major export market. In July 2002, the Japanese Government approved the amendment to the Building Standard Law which introduces new regulations on technical standards of building materials, in particular, the average permissible formaldehyde emission limits from wood based panels is reduced from 0.5 mg/l to 0.3 mg/l. The Ministry of Land, Infrastructure and Transport then issued an Enforcement Order and Notification to indicate the effective date of enforcement as July 2003.

b. *Export to Europe*

Europe is also Malaysia's major export market. European Union regulations have set the permissible formaldehyde emission at < 8 mg / 100 g oven dried board. The current emission demand is for levels between 8 mg /100 g oven dried board and 6 mg/100 g oven dried board. Under the CE marking for permanent construction panel boards (enforced in April 2004) the requirement is < 8 mg / 100 g oven dried board.

c. *Export to the US*

In April 2007, the California Air Resources Board (CARB), a unit of the California EPA, set new limits for formaldehyde emitted from composite wood product. The new limits are being implemented in two stages starting 1 January 2009. Under the implementation both imported and domestic wood composite products are regulated and must be third party certified and clearly labeled.

Table 1. Comparison of Worldwide Formaldehyde Standards for Composites (Using equivalent US large chamber test values)

Standard	**European E1**	**Japanese F*****	**Japanese F******	**CARB Phase I (2009)**	**CARB Phase II (2011)**
Maximum Emission Level (ppm)	0.14	0.09^	0.05^	0.18 (PB) 0.21 (MDF)	0.09 (PB) 0.11 (MDF)

^ Standard applies only to structural building materials and built-in cabinets
Source: Composite Panel Association, US

FRIM's Role
FRIM was set up to assist the forest industry as well as the related industries. As such FRIM has set up the required facilities to determine the formaldehyde emission from wood based panels in accordance to the requirements of the Japanese and European markets. These facilities have been accredited under the ISO 1705 and certified under ISO 9001. Facilities to meet the CARB requirements has been planned to be functional by mid 2010.

Recommendations

The issues on formaldehyde affect all players in composite wood industry. The issue is important to Malaysia as she is a major exporter of tropical wood products.

Other Asia Pacific countries are also important stakeholders in the wood industry, collaboration to solve these issues and other issues will be required in order that the wood industry can flourish.

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TANNIN RESORCINOL FORMALDEHYDE AS POTENTIAL GLUE FOR PLYBAMBOO MANUFACTURE

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Introduction

Urea formaldehyde (UF) resin is the most common adhesive that is used in Indonesian wood composite manufacture. The principal disadvantages of UF are that it is not resistant to weather and water, and produce a large amount of formaldehyde emission.

Copolymer tannin resorcinol formaldehyde (TRF) is a relatively new adhesive in the wood composite industry, which is known to be resistant to boiling water and has high bond strength. The tannin base adhesives for wood application were made by mixing Tannin:Resorcinol:Formaldehyde in various mole ratios.

Identification of copolymerization reaction of TRF formula was studied by X-Ray diffraction (XRD) and Differential Thermal Analysis (DTA). Then the optimum composition of TRF was used as the adhesive for making plybamboo. This new adhesive could be an viable option for wood processing and glue industries in order to maximize utilization of domestic resources, reduce dependence of glue import and develop wood adhesive industry that is environmental friendly.

The objective of this study was to develop a new composite-board type by using tannin base adhesives. The product should accomplish the standard for mechanical and physical properties of plywood and with formaldehyde emission conforming to Indonesian and Japanese standards.

Materials and Method

Tannin was obtained by extracting from *Acacia mangium* bark in hot water (1: 3). Then the extract was filtered. This process was repeated three times. All extracts were mixed in one place and its pH is made up to 10.5 with 40%NaOH. The tannin resorcinol formaldehyde (TRF) adhesive is made from tannin extracts copolymerize with resorcinol and formaldehyde. Mole ratios of tannin and resorcinol were 0.2, 0.5, 0.7, 0.9 and 1.1, whereas the ratio of tannin and formaldehyde were same, i.e. 1 mole. The copolymerization reaction of TRF formula was determined by Differential Thermal Analysis (DTA) and X-Ray diffraction (XRD). Other physical and chemical properties of the TRF′s optimum composition adhesives such as acidity (pH), solid contents, specific gravity and viscosity were also observed.

Plybamboo was made of tali (*Gigantochloa apus*) veneers of size 40 cm x 40 cm x 5.0 mm glued with tannin resorcinol formaldehyde (TRF) by hot-pressing at 130^oC. The physical–mechanical, glue bond quality and formaldehyde emission of the boards were tested and evaluated based on Indonesian (SNI 1999) and Japanese (JAS 2003) Standards for structural plywood.

Results and Discussion

Table 1 shows tannin resorcinol formaldehyde (TRF) adhesives made from *Acacia mangium* bark extract had 44.59–81.31% of crystallinity and melting transition of 228.08–277.14^oC. The TRF′s optimum composition was found in the copolymer with the mole ratios tannin: resorcinol: formaldehyde = 1:0.5:1, with a crystallinity of 51.33 % and melting transition at 277.14^oC.

Table 1. Summary of crystallinity (%) and melting transition temperature (^{o}C) of TRF adhesives and the components

Component	Crystallinity	Melting transition temperature
Tannin	42.89	230.47
Resorcinol	85.98	226.86
Paraformaldehyde	69.18	128.59
T:R:F = 1:0:1	81.31	124.65
T:R:F = 1:0.2:1	44.59	228.08
T:R:F = 1:0.5:1	**51.33**	**277.14**
T:R:F = 1:0.7:1	69.20	265.84
T:R:F = 1:0.9:1	61.40	254.44
T:R:F = 1:1.1:1	54.24	236.33
PRF	***51.53***	***273.04***

The TRF adhesives have good quality comparing to phenol formaldehyde (PF) adhesive based on Indonesian standard (SNI 1998), but it is not as good as phenol resorcinol formaldehyde adhesive (import) (Table 2).

Table 2. Summary of TRF adhesives characteristics

Properties	TRF	PF *	PRF **
Visual	L, RB	L, RB	L, RB
Specific gravity	1.08	1.165 – 1.2	1.15
Solid content (%)	46,0	40 – 45	57.03
Viscosity (Poise)	1.6	1.3 – 3.0	3.4
Acidity (pH)	10.5	10.0 – 13.0	8.0

Note: L, RB = Liquid, red-brown, * = SNI (1998), ** = Aczonobel (2003)

The plybamboo performances of TRF glued was showed on Table 3. The properties of plybamboo, except for MOE value, fulfill the Indonesian and Japanese Standards for structural plywood.

Table 3. Summary of ply bamboo properties

Properties	TRF	Standard	
		SNI	JAS
MOR, kg/cm^2	1,214.62	140	420
MOE, kg/cm^2	19,493	85,000	85,000
Bonding strength, kg/cm^2	38,40	7.0	7.0
Delaminating, cm	0	2.5	2.5
Formaldehyde emission, mg/L	0.043	0.5 – 5.0	0.3 – 0.5

The formaldehyde emission from the material is the lowest, therefore it is more environmentally friendly than many other adhesives.

Conclusion

The TRF′s optimum composition was found in the copolymer with the ratio mole of tannin: resorcinol: formaldehyde = 1:0.5:1, the crystallinity 51.33 % and melting transition at 277.14 ^{o}C.

It can be generally concluded that TRF adhesive could be a potentially good adhesive, and it can replace adhesive made from non renewable material such as urea and phenol adhesives contributing to climate change mitigation.

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LIQUEFACTION TECHNIQUE OF WOODY BIOMASS WASTE AND APPLICATION FOR BIO-BASED WOOD ADHESIVES

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Introduction

Wood-based materials are useful for decreasing the carbon footprint, but most existing adhesives for wood are petroleum-based, which is a serious disadvantage in terms of life cycle assessment. For environmental reasons, it is necessary to shift from petroleum-based adhesives to producing bio-based adhesives using natural resources as a sustainable green technology.

The technique of wood liquefaction was developed in Japan two decades ago (e.g. Shiraishi *et al.* 1986), and has the potential to convert final wood waste and other unused biomass into useful chemical intermediates. In particular, one of the most feasible applications of the technique is for making wood adhesives. This paper introduces the wood liquefaction technique and presents part of our experimental results, mainly the preparation of a phenol formaldehyde resin from phenol-liquefied wood (Li 2004), and an isocyanate adhesive from polyalcohol-liquefied wood (Tohmura 2005).

Materials and methods

Preparation of phenol liquefied wood adhesive (LWP)
Poplar (*Populus spp.*) wood meal, phenol and acid catalyst (weight ratio of wood and phenol to sulfuric acid of 0.7:1:0.05) were thoroughly premixed, then heated at 150°C for 90 min. After cooling and neutralization, sodium hydroxide aqueous solution and formaldehyde (F/P molar ratio: 0.5–1.5) were added to the prepared liquefaction products. The mixture was heated at 60°C to perform addition reaction for 1h, then the temperature was raised to 85°C to perform condensation reaction for 1 h.

Preparation of polyalcohol liquefied wood adhesive (LWI)
Sugi (*Cryptomeria japonica*) wood meal was liquefied at 150°C with a mixture of polyethylene glycol 400 and glycerin in the presence of a sulfuric acid catalyst. The weight ratio of wood:PEG:glycerin:H_2SO_4 was 1:2:1:0.03. The resulting liquefaction products were used directly to prepare isocyanate adhesives by mixing with polymeric diphenylmethane diisocyanate (pMDI) without removing the residue.

Making of plywood
Red meranti (*Shorea spp.*) veneers were laminated into three-ply plywood panels. The temperature and time of hot pressing for LWP and LWI were 135°C for 6 min and 120°C for 1.6 min, respectively. The tensile shear bond strength was determined in accordance with the Japanese Agricultural Standard (JAS) for plywood, normal state and cyclic steaming treatment.

Determination of formaldehyde emission
The emission of formaldehydes from plywood was determined in accordance with the JAS desiccator method for plywood. Other aldehydes were analyzed in accordance with the procedure in the previous paper (Tohmura 2003).

Results and Discussion

Behavior of wood liquefaction
In the LWP, most of the formaldehyde was quickly consumed in the first 30 min. Then, the amount of free formaldehyde decreased gradually to 0.31%. Cellulose is the most inaccessible fraction during wood liquefaction in the presence of phenol. In addition, the use of a high-performance mixer enhanced the wood liquefaction at wood to phenol ratios up to 1.2, leading to more efficient recycling of waste wood.

In the LWI, the residue content of the product gradually decreased in the initial stage. After 1.5 hours, the residue decreased quite slowly with reaction time. The residue content and the size of solid residue of LWI in this study were small enough (< 0.5 mm) to be used for adhesives.

Evaluation of bond performance

The test results of both shear strength and wood failure for the plywood bonded with LWP and commercial PF resin are illustrated in Figures 1 and 2, respectively. All the dry shear strengths of plywood exceeded that of the JAS criteria (0.68 MPa). After cyclic steaming treatment, however, only the shear strengths of plywood bonded with LWP2.4 (molar ratio of F:P is over 1.8) met the JAS criteria. The results suggested that resins with higher formaldehyde content have better heat and water resistance.

The test results of tensile shear strength and wood failure for the plywood bonded with the LWI are illustrated in Figures 3 and 4, respectively. The shear strength in the dry state in all samples met the JAS criteria. After cyclic steaming treatment, however, only the wet shear strengths of plywood bonding with the liquefied wood-based isocyanate resin with liquefaction time of 1.5 hours (LWI 1.5) exceeded the JAS criteria. The wet shear strengths of LWI resins apparently decreased with longer reaction time.

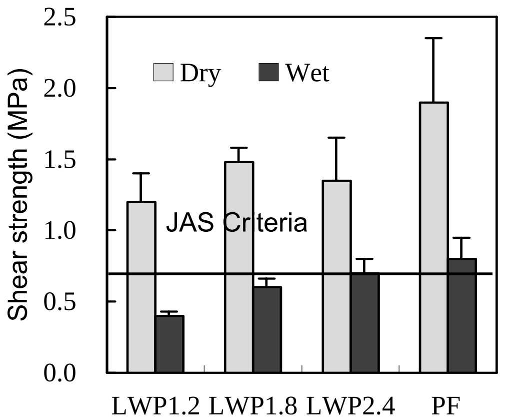

Figure 1. Shear strength of the plywood bonded with LWP and commercial PF resins

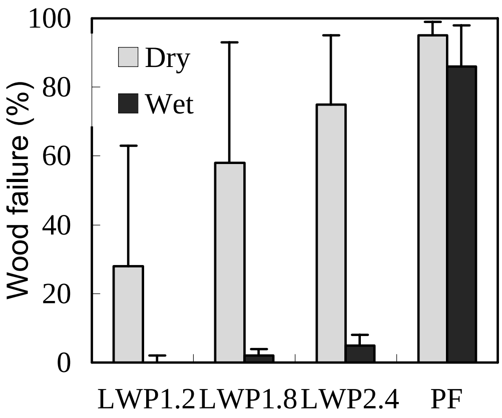

Figure 2. Wood failure of the plywood bonded with LWP and commercial PF resins

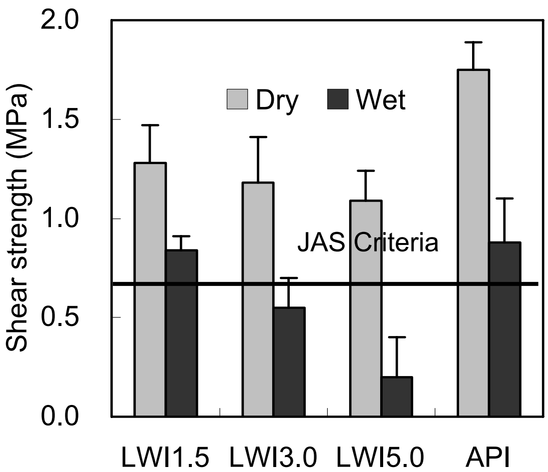

Figure 3. Shear strength of the plywood bonded with LWI and commercial API resins

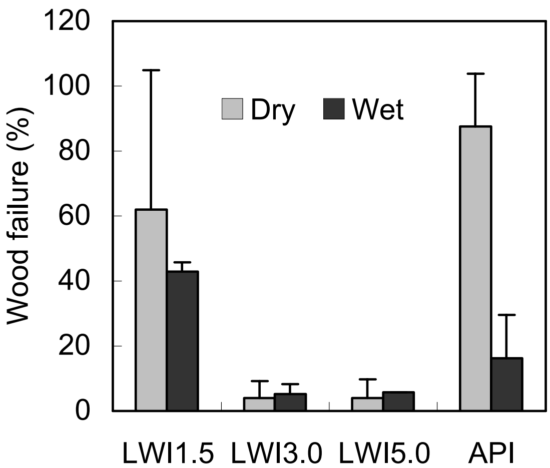

Figure 4. Wood failure of the plywood bonded with LWI and commercial API resins

Aldehyde emissions

The emissions of formaldehyde from the plywood manufactured with isocyanate resins were extremely low compared with the JAS severest formaldehyde emission grade F**** (< 0.3 mg/L), which is one of the safety advantages of phenolic and isocyanate binders for wood-based materials. Acetaldehyde emission from all plywood was also determined to be quite a low level.

Conclusion

From the above results, the liquefied wood-based adhesives of both LWP and LWI have excellent potential as wood adhesives because of their bond durability, safety and recyclability.

This liquefaction technique would enable the effective use of waste glycerin from the BDF biofuel production process.

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DESIGN AND DEVELOPMENT OF SAWDUST BURNER FOR KILN SEASONING OF TIMBER

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Introduction

Sawmilling industry is the biggest consumer of logs in Sri Lanka. According to Forestry Sector Master Plan (FSMP 1995) there are over 4000 privately owned sawmills. Most sawmills have wastage over 50% and the resulting sawdust is not utilized. Most timber in Sri Lanka are marketed unseasoned; mainly due to the lack of adequate drying facilities, and also the heavy demand for unseasoned timber for construction work. The high capital cost in setting up of drying kilns and the cost of fossil fuels to operate them had prompted this study which was planned to device a kiln to utilize sawmill waste (sawdust).

In this study, the present status of kiln seasoning industry was studied and a prototype sawdust burner was developed to generate heat for seasoning. Efficiency of the prototype saw dust burner was compared with two existing kilns used in Sri Lanka.

Methodology

A survey was carried out to investigate the status of timber seasoning facilities in wood-based industries, location of industries, capacity of seasoning chambers, operation technique and fuel type used.

Prototype sawdust burner was designed and developed after studying several existing designs: cyclonic suspension burner designed by the Natural Resources Institute of United Kingdom and two other conceptual models which use sawdust as fuel for heat generation. Several factors were taken in to consideration in designing. One major consideration was to build the burner at minimum installation and operational costs which enable it to use in the large-scale, and also for the medium- and small-scale industries. The prototype sawdust burner was coupled to the existing kiln chamber at the Department of Forestry and Environmental Science of University of Sri Jayewardenepura, Nugegoda, to carry out the test trials at laboratory level in controlled conditions.

Seasoning efficiency of developed sawdust burner was tested via several test trails. Sawdust feeding rate, heat increment of the kiln chamber, efficiency of the combustion chamber and heat transfer efficiency were determined. Efficiency of the heat generated from the combustion chamber was tested considering two factors: thermal efficiency and heat retention period of the combustion chamber. Special test was carried out for determine thermal efficiency. The temperature of the kiln chamber was observed at specific time intervals, and when it reaches a constant temperature after switching off the sawdust feeder and the heat retention time is plotted to check the heat retention time.

Seasoning efficiency of developed sawdust burner was compared with kilns at State Timber Corporation (STC) and Rowwood Lanka Industries, in terms of drying time, moisture content reduction, shrinkage and splitting of timber.

Green timber of Rubber in the form of 75 cm long, 8 cm wide, and 2.5 cm thick planks were used for this study. Ten sample boards were evenly distributed throughout stack of lumber for measurement of moisture content. To measure the moisture content of the timber planks, initial weight of the samples was taken by using a balance and in each run the weight of the samples were measured at regular time intervals and for the determination of drying rate following equations was used.

$$MC = \frac{(m_o - m_1)}{m_o} \times 100 \qquad (01)$$

where m_o – Average initial weight of the test timber sample (kg)
m_1 – Average oven dry weight of the test timber sample (kg)

$$\text{Drying Rate} = \frac{m_w}{T} * 100 \qquad (02)$$

m_w - Weight of the water removed in each stage (kg).
T - Time (hours)

Method of quality assessment was devised based on the presence of seasoning checks, splits, warp, loose knots and honeycomb. A list was prepared for these seasoning defects and their potential effects on lumber grade. The dimensions of each sample in the radial and tangential planes were measured from green to relevant drying stages

Percentage of splitting was determined by careful observations on the splitting present in the sample boards at each stage of the kiln operation:

$$\text{Splitting \%} = \frac{\text{Change in dimensions of the splits}}{\text{Original (green) dimensions of splits}} \times 100 \qquad (08)$$

(Srivaro 2008)

Results, Discussion and Recommendation

It was found that, in Sri Lanka four different types of technologies are used by sawmillers for heating their chambers. Fifty percent of millers use boilers to generate steam and 22% generate hot water for heating kiln chambers; 11% used dehumidification systems and 17% use direct-firing for seasoning timber (Figure 1). Capacities of the chambers commonly used in Sri Lanka vary between 100ft ^{3} to 1000ft^3 and two major seasoned timber species are rubberwood and mahogany.

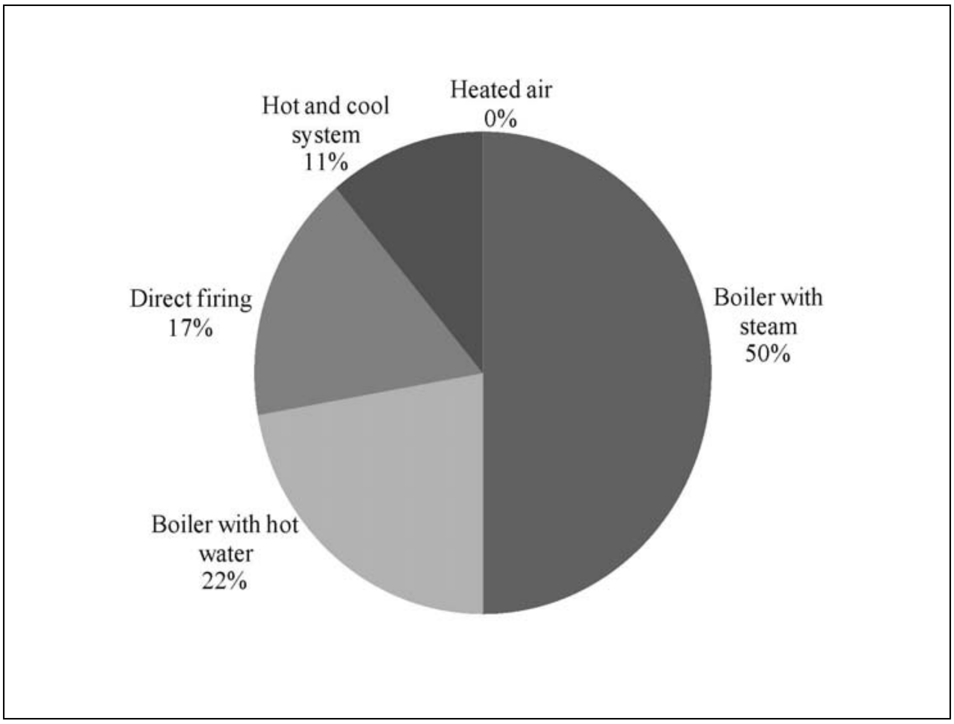

Figure 1. Heat generating techniques used for timber seasoning in Sri Lanka.

Figure 2. Prototype sawdust burner at the university premises

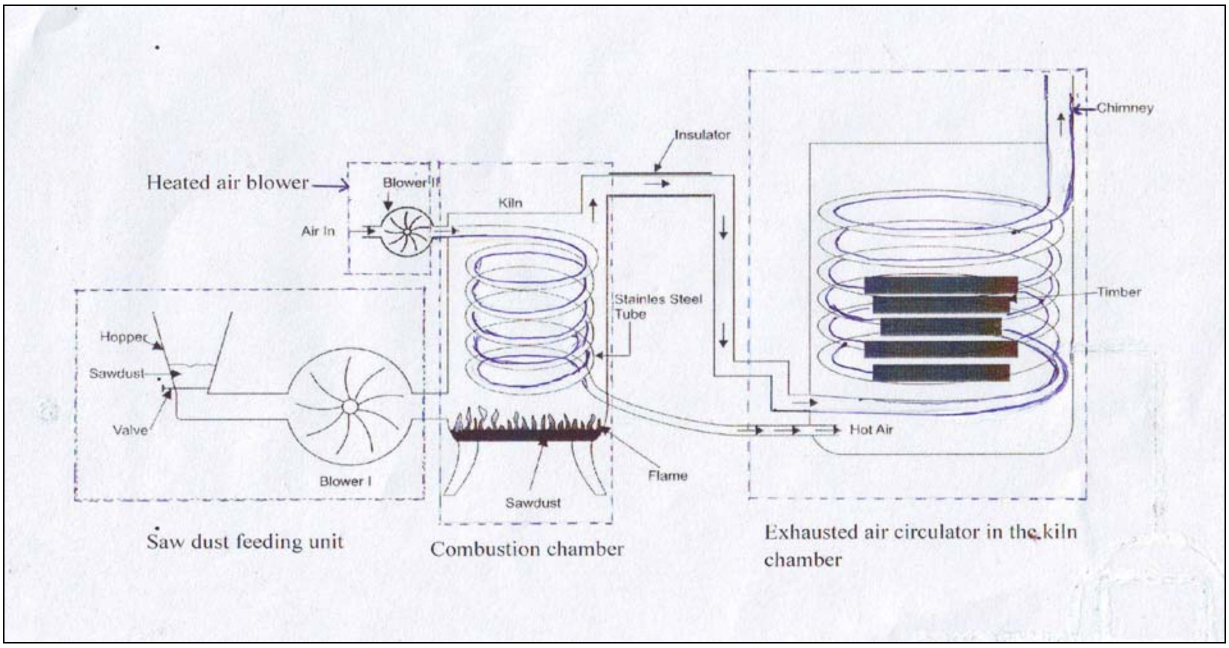

Figure 3. Prototype sawdust burner and the kiln chamber with exhaust heated air circulation tubes

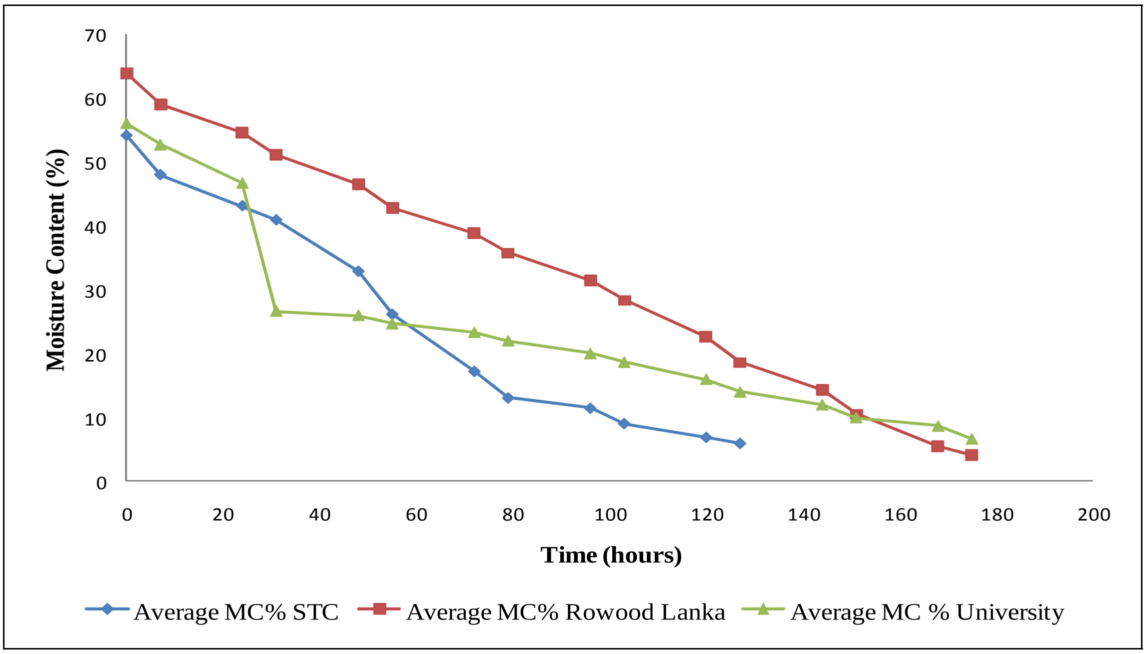

Figure 4. Relationship between drying time (hours) and moisture content (%) of rubberwood

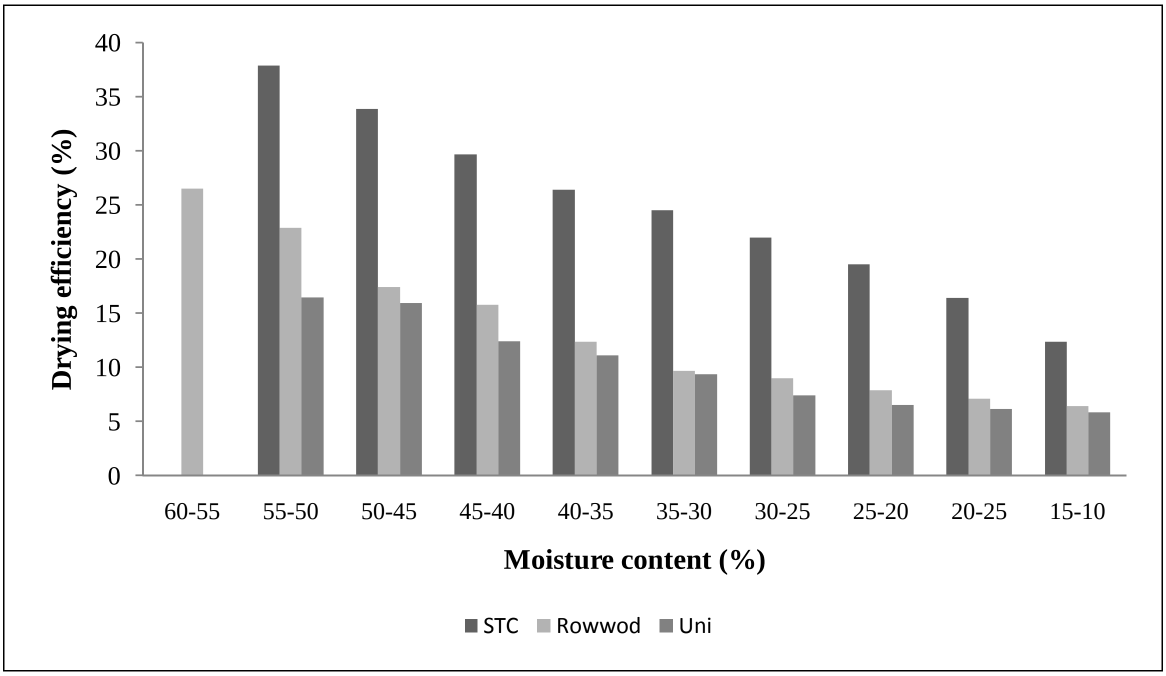

Figure 5..Drying efficiency (%) of the three kilns in each stage of moisture content

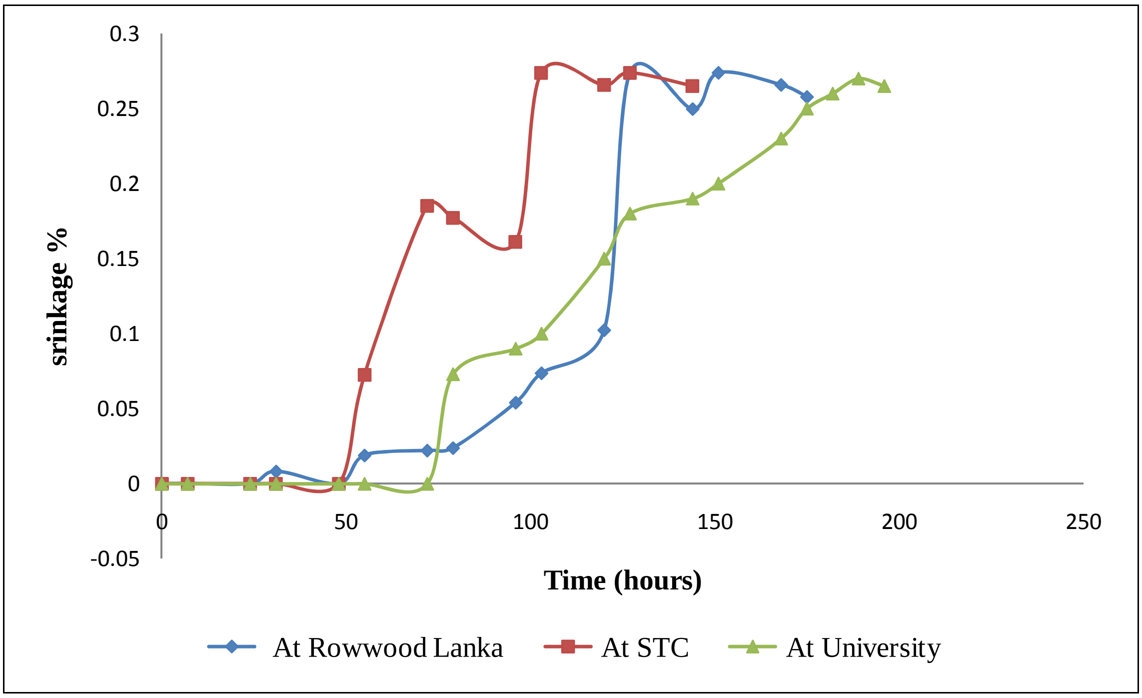

Figure 6. Relationship between shrinkage percentage (%) and time (hrs) of rubberwood

The prototype sawdust burner developed in the present study consists of four main parts. Sawdust feeding unit, combustion chamber, heated air blower and exhausted air circulator inside the kiln chamber. Sawdust feeding unit consists of a motor operated sawdust blower and sawdust hopper. The combustion chamber is to burn sawdust to generate heat and one of the main design considerations is to increase the heat retention time in the combustion chamber and to minimize heat loss. The burning chamber is made of iron and coiled, stainless steel pipe. Air blower is used to blow clean heated air to the kiln chamber, the air blower is fitted to the lower end of the stainless steel tube. Hot exhausted air from the burning chamber; circulate inside the kiln chamber through stainless steel tube system which is fixed to the kiln chamber walls before release to the atmosphere (Figures 2 and 3).

The thermal efficiency of the sawdust burner was found to be 0.0045kJ/kg. Heat transfer efficiency of the system was 68%, the sawdust feeding rate of sawdust feeding unit was 18.5g per second and the heat retention time in the kiln chamber without feeding sawdust was approximately 3 hours with temperature of 50°C. It was one of the main advantages of this burner.

Results show that the prototype sawdust burner has lower drying rate compared with the kilns at STC and Rowwood Lanka Industries. However, in terms of drying defects, the university kiln showed lower defects compared with other two kilns. Power consumption, installation cost and operational cost of the prototype sawdust burner were lower than the other two kilns. Timber in STC kiln and timber in Rowwood Lanka reached FSP in 50 hours and university kiln reached FSP in 70 hrs. (Figure 4).

Figure 5 shows that fastest drying rate in the SCT kiln and drying rate is comparatively lower in Rowwood Lanka and lowest drying rate is in university kiln.

However this type of slow drying is better in terms of reduction in drying defects such as splitting. Splitting was found to be lowest in the university kiln (Figure 6) indicating that this kiln will produce the best quality timber compared with other two kilns.

In terms of simplicity, convenience of the process and the quality of the seasoned timber, the university kiln is equally efficient as the other kilns used in STC and Rowwood Lanka.

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Acknowledgements

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Mr W.A.T. Banadara Wikramasinghe, Managing Director of Rowood Lanka Industries (Pvt) Ltd.
Mr. Nimal Perera, Managing Director, EcoPro Technologies to provide digital thermometer to carry out tests in saw dust burner.

THE ROLE OF FOREST PRODUCTS IN CARBON SEQUESTRATION, STORAGE AND CONSERVATION IN BHUTAN

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Introduction

Nestled between two giant neighbours – China in the north, and India in the south, west and east – Bhutan occupies a total geographical area of 38,394 km^2 in the eastern Himalaya. The total population is estimated at 634,982 (PPD 2008) of which 79% resides in the country side and depends on natural resources for meeting their basic necessities. The area under forests is estimated at 72.5% of the total geographical area (FAO 2006). Approximately 34% of the forest area is economically accessible and harvestable using mechanized logging under current circumstances (Dhital 2002). Harvesting is administered through forest management units (FMUs) which focus on timber supplies to urban communities. In addition, forest within and outside FMUs supplies timber to rural communities on an *ad hoc* basis. About 51% of the total geographical area is under the Protected Area Networks of Bhutan and harvesting is restricted legally. Community forestry is gaining momentum and it is estimated that about 4% of the forest area will be designated as Community Forests by 2013 (DoF 2009).

According to FAO (2006) the total growing stock of wood in the forests of Bhutan has been estimated at 621 million cu m, which gives a growing stock density of 632 m^3/ha. The total forest biomass is estimated at 766 million tonnes comprising of 503 million tonnes of above ground biomass, 187 million tonnes of below ground biomass and 76 million tonnes of coarse woody debris. FAO (2006) estimated that Bhutan's forests sequester about 251 million tonnes of carbon in above ground biomass and 223 million tonnes in forest soils. The capacity of Bhutan's forests to sequester carbon dioxide (CO_2) could potentially be increased through the practice of sustainable forest management encompassing efficient utilization of wood, reducing wood harvesting, processing and milling wastages and non-wood forest products development. In order to promote efficient utilization of wood products and carbon sequestration and storage, it is important to examine wood wastages at different stages from wood production to consumption and design ways to minimize wastages and concomitantly contribute to green house gas (GHG) reduction.

Timber harvesting technology and wood wastage

Harvesting of timber and firewood is highly organized and visible than any other forest products in Bhutan. The harvesting and regeneration of forest resources is administered through FMUs and Working Schemes (WS) based on the management plan objective of ensuring sustained yield for social and economic benefits without compromising environmental sustainability.

Commercial harvesting involves extraction of trees from forests using skyline cable yarding. The use of imported machineries aims to minimize damages to forests and addresses labour shortages, however, do not extract and transport all felled trees from the forest. Felling of Bhutan's old-growth forests invariably accompany damages to cut and uncut trees. Cut trees suffer from bole fractures and uncut trees branches are snapped leading into production of more lops and tops. The inherent limitation in the capacity of cable crane to uplift large size tree adds to the quantity and density of coarse woody debris on the forest floor. Darabant (2008) estimated the forest floor coarse woody debris density at 10% which supports natural regeneration of Himalayan Hemlock but this practice contradicts by releasing CO_2 upon decay. The mechanized harvesting damaged logs during stacking are left behind in the logging depots and under high humidity and warm climate conditions; microorganisms accelerate the decay process and release of CO_2. Timber harvesting and transportation by rural communities entail felling, cross-cutting and debarking on the forest floor and downhill dragging of round logs over a long distance. Round logs are either sawn in mills or hand sawn traditionally. The latter method is desired by rural communities. Traditional hand sawing incurs substantial timber wastages accounting for 59% compared to 41% in sawmills (Gyeltshen et al. 2008). Dragging exposes forest soil and increases its vulnerability to erosion and eventually forming gullies and ravines causing forest degradation further stimulating release of CO_2. Minimizing soil disturbances during harvesting and timber wastage from damages can contribute to GHG reduction. Wood used in urban and rural homes is untreated hence shortens durability and also carbon storage lifespan.

Wood residues and charcoal to meet the demand of ferro-alloy, and Bhutan carbide and chemicals industries, are sourced from forest by in situ burning releasing CO_2. Until recently, vast volumes of sawdust generated by sawmills were treated as waste. The commissioning of briquette machineries converted sawdust successfully as firewood substitute for heating urban homes. Such innovative wood-based industries not only promote efficient utilization of wood wastes but also reduce CO_2 emission. The use of briquette as firewood substitute save cutting down thousands of trees for firewood consumption which stands at 1.92 m^3 per capita (DoF 2002). Electricity is a clean firewood energy substitute in urban homes and institutions but not entirely in rural homes due to high transmission costs. Bhutan aims for electricity self-sufficiency, and its generation from hydropower plants contributed 38% of gross domestic product (GDP) in 2000 (DoE 2009). Most rural communities use firewood for cooking and heating, accounting for 42% of national energy supply. Wood energy, however, remains to be integrated into future energy security. Wood energy is climate-friendly and Bhutan's forests can benefit by engaging in bio-energy development and contribute to finance sustainable forest management.

Non-Wood Forest Products

Harvesting, processing and marketing of Non-Wood Forest Products (NWFPs) from natural forests provide opportunities not only to earn incomes but also carbon conservation. Potential commercial NWFPs and their product developed include: lemon grass (*Cymbopogan flexuosus*), bamboo (*Neomicrocalamus andropogonifolius* and rattan (*Calamus acanthospathus*). The total revenue generated by NWFPs from 2003-2007 amounts to Bhutanese ngultrum (Nu.) 146.48 million compared to Nu. 85.94 million (exchange rate 1 US$ = Nu. 45) from wood products, indicating the importance of NWFPs in forest sector development. Certified organic lemongrass oil is used in perfumes, soap, and cosmetics and pharmaceutical preparations in developed nations (FAO 1996). Bio-Bhutan which is a private entrepreneurship exports certified organic oil to Asia, Europe and United States of America with price ranges from US$ 20–23 per kilogram of oil (Yangzom *et al*. 2008). Lemon grass-Chirpine (*Pinus roxburghii*) is a fire-managed ecosystem. Observation records from 1998-2002, however, show highest incidence of forest fires (DoF 2002) burning thousands of hectares of forests and spewing CO_2 into the atmosphere in eastern Bhutan. Sustainable management of the lemon grass-Chirpine ecosystem can ensure continue harvesting of lemon grass and concomitantly sequester carbon in woody biomass and soils. Bamboo and rattan grows under the shade and support of warm and humid temperate and sub-tropical broad-leaved forests of eastern and southern Bhutan, and contributes 66% of the gross household income (Moktan *et al*. 2009). The local communities are specialized in the manufacture of high quality finished products designed for the export markets. Bamboo and rattan can be sustainably cut without jeopardising the forest integrity and concomitantly sequester carbon in woody biomass and soils. Efforts are underway to expand this high intensity carbon cropping bamboo-rattan ecosystem under sustainable management regimes empowering local communities the resource use rights. Forest products use rights alone, however, are insufficient to compensate local communities, the benefits of carbon sequestration and forest conservation.

Conclusion and Recommendations

Forest sector in Bhutan can contribute to carbon sequestration, storage and conservation in many ways. Wood-based industries can be climate-friendly by pursuing efficient harvesting, processing and utilization of wood products and NWFPs. The national forest policy clearly stipulates the promotion of "an economically viable and efficient forest-based industry utilizing both wood and non-wood products aimed at adding value" however, the strategies to achieve this outcome remains unclear.

The following strategies relevant to wood-based industries are suggested:

- Efficient wood production and utilization reduces GHG emissions through minimizing woody biomass and soil disturbances during harvesting, reducing milling waste and wood wastage, and producing durable products through treatment of woods.

- In view of 42% energy contribution by woodfuel, climate-friendly wood-based bio-energy and its development needs integration in forest sector policies and strategies to support financing sustainable forest management.

- In order to attract new wood-based investment opportunities, the forest sector must establish clear and consistent policies for forging and fostering public-private-partnership on forest resource development, providing secure access to forest resources and rights.

- Unnecessary impediments to market efficiency and access need to be removed.

- Measures to encourage the development of value-added forest industries include provision of equity capital to wood-based and NWFPs cottage industries, liberalization of investment policy, and green products development.

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WOOD WASTE UTILIZATION FOR WOOD COMPOSITE INDUSTRIES IN MALAYSIA

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Abstract

Malaysia has an abundant supply of wood waste generated from logging and processing activities throughout the country. In addition, there are also agricultural by-products from rubber and oil palm plantations which can be useful ligno-cellulosic resources for various composite products such as particleboard, cement-bonded board, medium density fibreboard (MDF), oriented strand board (OSB) and wood polymer composite (WPC). Research on wood composite products at Forest Research Institute, Kepong, was established since the 1960s to enhance the utilization of substantial amount of wood residues generated from sawmill and plywood mills. Various studies were conducted to utilize these wood residues for particleboard manufacture and later followed by other type of wood composite products. In this regards, the sawmill wastes were processed into wood chips by drum-chipper and later refined to smaller particles by using knife-ring flaker. Synthetic resin such as urea formaldehyde (UF) is normally used as adhesive for particleboard manufacture to form a panel of various thicknesses and pressed under controlled pressure and temperature. Ordinary Portland cement is another inorganic binder which is normally used to blend with wood particles before consolidated on caul plate and pressed at ambient temperature and specific pressure to produce cement-bonded particleboard. From 1980 to 1990, there were quite a few particleboard and cement-bonded board mills established in Malaysia. The R & D and commercial application were expanded by using agricultural by-products such as rubberwood and oil palm fibres residues for bio-composite products. The technology was further developed to refine the woody materials into fibres by thermo-mechanical process to produce MDF with better strength and flexibility to supplement wood utilization in the furniture industry. Currently, Malaysia has nine MDF plants with capacity to produce 1.202 million m^3 per annum and has become the third largest exporter of MDF in world market since 2002. The R&D activities is still continuing towards advanced bio-composite products such as oriented strand board (OSB) and wood polymer composite (WPC) products with the emphasis to improve the recovery yield of woody materials available in the country.

Introduction

Malaysia has been known as a major exporter for timber and wood-based products in the world. It has been reported that Malaysia exported RM 22.5 billion per annum of various timber and wood-based products in year 2008 (NATIP 2009).

During the last few years, there was paradigm shift to preserve our forest for the sake of biodiversity and environment purposes. Eventually the paradigm shift also occurred towards the utilization of alternative resources such as under-utilized timber species and non-wood forest produce for biocomposite products to be used in furniture manufacture. As an exporter country, Malaysia has no choice but to continuously making improvement in order to remain competitive in the world market.

Priority should be given towards efficient processing and utilization of wood resources available, improving quality of wood and wood-based products against bio-deterioration agents, promoting the aesthetics and strength values of timber and development of novel products from wood. Emphasis should also be given towards the efficient utilization of wood and non-wood resources for wood composites, pulp and paper, and biomass and energy generation from wood residues.

Wood Composites

With the current challenges faced by the wood industry in terms of raw material supply and increased competition from low cost producing countries, the wood composite research is now geared towards the utilization of available wood and non-wood resources, the development of higher valued-added composite products, as well as involving in both national and international activities.

During the Ninth Malaysia Plan, the emphasis was given towards the development of wood–based products in order to enhance the performance and utilization of these products for manufacturing of furniture and building components. Research in wood composites focuses on development of reconstituted wood products from biomass and the formulation of resin binders of low formaldehyde emission. The products include MDF, particleboard, cement-bonded particleboard, oriented strand board (OSB), wood polymer composites and gypsum-bonded board.

Development of Wood Composites Industry in Malaysia

Wood composite products such as particleboard and medium density fibreboard are also becoming important export products in the country. Currently, Malaysia has 11 particleboard mills, 11 MDF and 1 cement-bonded particleboard (CBP) mills in operation (Tables 1 and 2). These wood composite products mainly use rubberwood, sawmill wastes of mixed hardwood species and oil palm empty fruit bunch fibres. The production capacity of particleboard, MDF and CBP are estimated to be about 1.92 million m^3, 1.153 million m^3 and 70,000 m^3 per year respectively.

Almost 80% of the wood composite products are being exported and generated revenues of more than RM 5 billion annually. Statistics has indicated that Malaysia exported more than 1 million m^3 per year of MDF and has become the second largest MDF exporter behind Germany since 2001 until 2004. However, in 2005, France exported 1.144 million m^3 MDF and became the second largest exporter overtaken Malaysia which exported 1.065 million m^3. Both particleboard and MDF have been widely used to support the furniture industry in the country either for the local or the export markets.

Table 1. Particleboard Manufacturers in Malaysia

Mill	Location	Raw materials	Capacity (m^3/day)
Mieco (2 mills)	Kuantan, K. Lipis	RW + SW + kenaf	2600
Pahanco	Kuantan	Sawmill wastes (SW)	80
HeveaBoard (2)	Gemas	RW + A. mangium	1200
Sinora	Sandakan	SW	200
Jayakuik	Sandakan	SW + A. mangium	200
Subur Tiasa	Sibu	SW	300
Merbok Pbd	Sg. Petani	Rubberwood	250
Segamat Pbd	Segamat	Rubberwood	200
Isotop	Muar	RW + OPF	100
Tian Siang	Sitiawan	EFB	100
CGC Wood Ind	Merlimau	RW + SW	110
Total Capacity	**(1.92 mil. m^3/year)**		**5340**

Notes: RW: Rubberwood
SW: Sawmill wastes
EFB: Oil Palm Empty fruit bunches

Table 2. MDF Manufacturers in Malaysia

Mill	Location	Raw materials	Capacity (m3/day)
Takeuchi	Johor Bahru	Rubberwood	300
Merbok	Sg. Petani	Rubberwood	700
Hume	Nilai	Rubberwood	470
Donwha MDF	Nilai	Rubberwood	370
Evergreen	Batu Pahat	Rubberwood	700
Robin	Mentakab	RW + A. mangium	370
Guthrie	Kulim	Rubberwood	370
Segamat Panel	Segamat	Rubberwood	300
Daiken	Bintulu	Mixed Hardwood	315
Samling	Miri	Mixed Hardwood	285
Agro Bio Fibre	Gemas	Oil Palm EFB fibre	55
Total Capacity	**(1.525 mil. m^3/year)**		**4235**

Conclusions

Malaysia has anticipated the declining volume of timber for solid wood production in the near future. A paradigm shift is required to improve the recovery yield of existing forest resources as well as agricultural by-products available in order to remain competitive in the world market. It was suggested that the country should focus on more down-stream products such as wood composites, biofuels and other value-added products industries to optimize the utilization of biomass available. This is to support the recent launched of National Timber Policy (NATIP) by the Government of Malaysia.

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CONVERTING SAWDUST INTO HIGH QUALITY ACTIVATED CHARCOAL AS CARBON STORE

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Introduction

Utilizing wastes from forestry activities can be troublesome, hence these are often just left to decay, piled up, or burnt, thereby causing negative impacts on the environment (Pari and Roliadi 2004). One potential viable option is to convert these wastes into useful products such as high quality activated charcoal. The objective of this research was to improve the quality of activated sawdust charcoal with lower concentration of H_3PO_4 solution as a soaking agent and higher temperature (i.e. activation up to 800^o - 900^oC) of gas oxidation.

Materials and Methods

Prior to the activation, sawdust charcoal, produced through the carbonization of sawdust in a retort kiln, was soaked in H_3PO_4 solution for 24 hours at three different concentrations: 0, 5, and 10%. The sawdust charcoal was activated by placing it in a retort with the temperature held at three levels: 800, 850, and 900^oC. During the activation process, the water vapor containing $(NH_4)_2CO_3$ solution, was directed back into the retort for three different durations: 30, 60, 90 and 120 minutes.

Results, Discussion and Recommendations

The soaking of sawdust charcoal in low H_3PO_4 concentration prior to its activation and with activation temperature held at 900^oC for 90 minutes; are considered to be the best set of conditions to produce a high quality activated sawdust charcoal. This process resulted in a recovery of 50.98% with a low moisture content of 2.96%, and a composition of ash 25.76%, volatile matter 16.27%, and fixed carbon 57.96%, respectively. Adsorptions capacity on $CHCl_3$, C_6H_6, I_2, and methylene blue was consecutively 28.84%, 16.02%, 770.28 mg/g, and 184.76 mg/g, while the surface area of the activated charcoal reached 685.09 m^2/g.

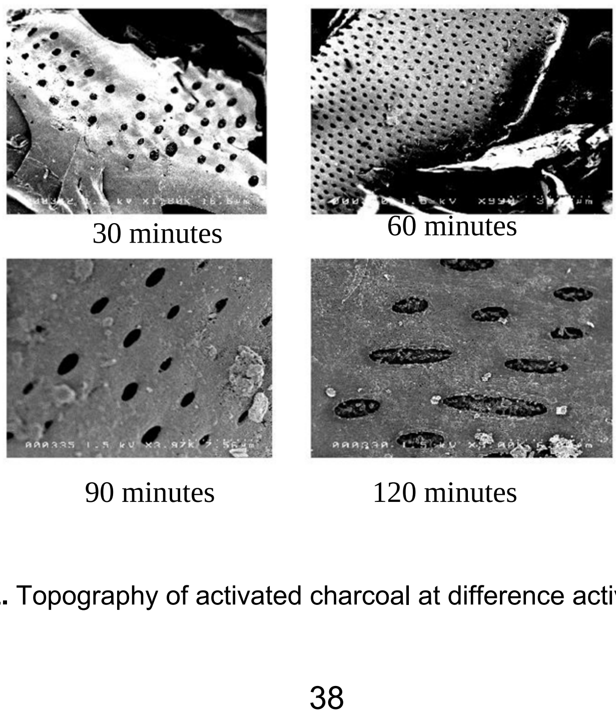

Figure 1. Topography of activated charcoal at difference activation times

Although the degree of recovery was slightly low, the qualities of the activated charcoal, however, may be improved by allowing air to flow into the retort during the activation. With this method, the degree of recovery was 13.33%; moisture content 6.25%; ash 18.31%; volatile matter 3.99%; fixed carbon 77.70 %; adsorptions on $CHCl_3$, C_6H_6, I_2, and methylene blue at 37.07 %, 10.72%, 1187.0 mg/g, and 284.7 mg/g, respectively. Surface area went up to 1055.7 m^2/g.

High quality activated charcoal from sawdust with high carbon content and surface area is good carbon store. Application of activated charcoal mixed with chicken manure on *Gmelina arborea* plantation could increase the total amount of biomass up to 56.15% (Lempang *et al*. 2009). In another case, total biomass of *Gynura pseudochina* increased from 89 to 233 g after 90 days by using activated charcoal mixed with compost from agricultural waste (Pari and Ganim 2009). Because of the increase in total biomass, the absorption capacity of CO_2 will also be increasing. Activated charcoal could also fix the nitrogen and effectively reducing N_2O emissions from the soil (Condron *et al*. 2009)

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ENERGY-EFFICIENT MANUFACTURING PRACTICES AMONG WOODEN FURNITURE MANUFACTURERS IN MALAYSIA

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Introduction

It has been estimated that the total energy consumption in the wooden furniture manufacturing industry in the South East Asian region in 2008 was valued at US$ 1 billion (Anon. 2008). Further, as energy cost can account for almost 14% of the total manufacturing cost, energy cost is increasingly becoming a competitive factor in the sector. Despite its socio-economic importance to many developing countries throughout the world, the wooden furniture industry is under increasing scrutiny as a result of its labour and energy intensive nature, coupled with the fact that it is starved of capital investment. Against the background of the escalating energy cost worldwide, energy efficient manufacturing practices is being strongly advocated throughout the world. Although, energy efficiency in the manufacturing industries has been gaining importance in Malaysia in recent years, reports on the subject remain limited (Ratnasingam and Wagner 2009). This is often attributed to the fact that energy cost is regarded as an indirect cost element, which negates direct measurement. Hence, the cost of energy is usually established on the basis of estimates or historical data. The lack of information not only impairs efforts to improve productivity, but also makes competitive assessment rather inaccurate. Therefore, a study was conducted to evaluate the current state of energy efficient manufacturing practices among wooden furniture manufacturers in Malaysia.

Methodology

As part of a study commissioned by the United Nations Industrial Development Organization (UNIDO), a survey of 50 wooden furniture-manufacturing outfits in Peninsular Malaysia was carried out in 2007/08. The respondents were large wooden furniture manufacturers (i.e. factories with more than 100 workers in employment, with an annual sales turnover in excess of US$ 5 million), who had volunteered to be in the study (Ratnasingam and Wagner 2009). The questionnaire-based survey was carried out with the assistance of the national furniture trade organization. The questionnaire had two parts; Part I evaluated the current energy-efficient technologies in use in the respondent factories, while Part II identified the areas where potential energy savings could be achieved. Further, a walk-through the factory shop floor was implemented to observe and assess the validity of the data collected through the questionnaire. The questionnaire was developed after extensive consultation with industrial experts, and was pre-tested in 10 factories in the Klang Valley, in Peninsular Malaysia, to ensure its practicality and ease of gathering responses.

Results and Discussion

The results of the study revealed that energy-efficient manufacturing practices among wooden furniture manufacturers in Malaysia were relatively low, as the average wood processing loss reported was 36.7%. In terms of heating energy, 29% of the heating energy produced was lost to the environment, as the surplus heating energy produced from the boiler did not find any application. On the other hand, the heating energy demand from the adhesive and coating applications were relatively low in the factories surveyed, and the total energy demand was easily met by internal energy sources. In terms of the electrical energy consumption, the machining operations were the largest consumers, accounting for 78.4% of total consumption. However, the actual energy demand for the cutting processes was relatively low at 9.7%, while the dust extraction system accounted for 62.5% of the total energy consumption. Energy expanded during the idle machining time accounted for 14.3%, suggesting that energy efficiency within the wooden furniture manufacturing industry in Malaysia could

be significantly improved. Energy inefficiency in the furniture manufacturing industry was attributed to the lack of environmental consciousness within the wooden furniture industry. The poor work culture prevalent among the workforce in the industry and the adoption of inefficient manufacturing technologies are the other prevalent reasons contributing towards energy inefficiency.
The study also revealed that substantial energy savings could be achieved in the areas of wood drying, curing of adhesives and costing, wood machining processes, waste reduction and pneumatic system (Table 1). Nevertheless, the main reasons that deter factories from accomplishing the potential energy savings are: (1) lack of management commitment, (2) use of unskilled workers, (3) poor insulation, (4) poor dust extraction, (5) poor energy transmission and (6) hidden cost. The fact that energy cost is often treated as an indirect cost reduces the necessity of an accurate assessment of its cost. Further, the prevailing high throughput and high volume mentality among the manufacturers also somewhat distorts the energy cost as being insignificant to be accounted for accurately.

Table 1. Potential for Energy Savings in the Wooden Furniture Industry

Work Station	Potential Energy Savings
Wood Drying	Unbalanced Starting Moisture Content of Stock, Poor Kiln Practices, Poor Insulation, Lack of Energy Recycling
Curing of Adhesive and Coating	Lack of Energy Recycling, Improper Design of Curing Oven, Over Heating Capacity
Wood Machining Processes	Poor Dust Extraction, Idle Time Losses
Waste Reduction	Wasteful Operations on Shop Floor
Pneumatic / Compressed Air System	Leakages in Transport System, Moisture Reducing Effect

This study provides a detailed insight into the status of energy-efficiency within the wooden furniture manufacturing industry in Malaysia. The fact that energy cost is artificially kept low through subsidies and regulatory measures, suggest that the economics of energy in the country does not encourage efficiency. This market phenomenon has a far-reaching implication on the future of energy-efficiency manufacturing practices not only in the wooden furniture industry, but also throughout the manufacturing industries as a whole (Anon. 2008). Perhaps, the adoption of environment management systems, such as the ISO 14001 would pave the way for greater energy efficiency manufacturing practices within the wooden furniture industry, as reported by Ratnasingam and Wagner (2009).

In some previous studies, as reported by Ratnasingam and Wagner (2009), the adoption of the ISO 14001 environment management system brought about a transformation in energy efficiency within the manufacturing industries. This is attributed to the greater attention paid to automation, waste reduction, process efficiency and the training of workers, which in turn contributed to greater energy efficiency of the manufacturing practices.

In this context, it must be emphasized that the application of energy efficiency practices is a market-driven phenomenon that is often put into use when conditions makes it a necessity to save energy. It is therefore apparent that unless, economic disincentives are put in place to pave the way for energy efficiency practices, the reality of such practices in the country may remain ambiguous.

Conclusions

It appears that energy-efficiency manufacturing practices within the Malaysian wooden furniture sector are very much at the infancy stage, and future application of such practices will depend on market incentives that encourage it. Although, there is substantial energy saving potentials within the wooden furniture industry, it implementation appears somewhat lukewarm due to its perceived insignificant economic contribution. Nevertheless, with increasing global energy cost, manufacturing practices in the wooden furniture industry could gain substantial cost savings by assimilating energy efficient principles, which in turn will help boost the environmental sustainability of the industry as a whole.

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SUSTAINABLE HARVESTING AND VALUE ADDITION OF MAPS IN COMMUNITY FORESTS IN DOLAKHA, NEPAL

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Background

Nepal exports a significant volume of non wood forest products (NWFPs) and medicinal and aromatic plants (MAPs). The volume and value of NWFPs traded in the international and domestic market are very difficult to estimate due to lack of available and reliable data. There are different reports from various individuals and organizations regarding the trade of NWFP. Hertog (1997) reported that NPR21.5 million (USD1=Nepalese Rupee (NPR)75) worth of NWFP was collected from the Salyan district alone. Likewise, in the same year, the value of medicinal plants in Gorkha district was reported at NPR12.13 million corresponding to a volume between 180–417 tons per year (Olsen 1997). Report by the Trade Promotion Centre estimated at NPR 17 million per year. But this report does not consider the unrecorded figures of NWFP that are directly exported to India. Another report, prepared by Asia Network for Sustainable Agriculture and Bio-resources (ANSAB), estimated that each year Nepal sells medicinal plants and NWFP worth above USD18 million.

Dolakha, a mountainous district in Central Nepal, is also rich in NWFPs. Varied topography, climate and edaphic conditions favour the growth of various MAPs. In rural areas, harvesting and selling of such MAPs improves the local livelihood and also reduce the pressure on forests for major forest products. Since MAPs are harvested in low volume compared to timber and fuelwood, their sustainable harvesting will also substantially contribute to maintain carbon sink and ultimately help in climate change mitigation. But due to excessive commercial harvesting, these MAPs are disappearing fast.

Essential oil extraction: value addition to raw MAPs

The volume of essential oils extracted from raw MAPs would be very less (less than 1% for all the 7 MAPs mentioned in Table 1). But value of such essential oil would be significantly increased due to value addition when the raw material is converted to essential oil. The low volume will also reduce the transportation cost. Deudhunga Multipurpose Cooperatives (DMC) has established distillation units in 3 different clusters in Dolakha to extract essential oils from MAP. So far, the units have extracted essential oils from 7 MAPs, collected from 18 certified forests in the district. These include wintergreen, anthopogon, juniper, calamus, mugwort, Nepalese pepper and silver fur. (See table 1 for part use for essential oil extraction). Himalayan Bio-Trade Ltd (HBTL) is engaged in marketing and trading of such essential oils.

All the distillation units are being managed in such a way that share of pro-poor groups have also been invested to run the enterprise. The total asset own by these three clusters have been estimated around USD28,392 of which DMC has 40% share, 18 community forests have 30% share and pro-poor user group has remaining 30% share. Nepal Swiss Community Forestry Project has contributed the share for of pro-poor users group. This inclusive model of including pro-poor people has been replicated in other parts of Nepal.

Earlier mild steel (MS) distillation units were used for essential oil extraction. It was a very energy extensive practice having no attached boiler. Some of the essential oils produced in MS unit were prone to corrosive action. But later with the support from GEF Small Grants Programme of UNDP, stainless steel (SS) distillation units with boiling system have been introduced which enhanced production capacity both in terms of quality and quantity. In MS distillation unit, 150 kg of firewood was required to distil 300 Kg of raw wintergreen. The distillation yielded 1.5 kg (O.5%) of wintergreen oil in 12 hours. On the other hand, the new SS distillation unit consumed 160 kg of firewood to distil 500 kg of raw wintergreen. It produces 3.5 kg (0.7%) wintergreen oil in 11 hours. The wintergreen plant residue after oil extraction is dried and can be used as fuelwood for the boiler. Thus there would be no further requirement of firewood from forest making the product greener and climate change mitigation friendly. The SS distillation unit produces quality wintergreen oil retaining natural brown color. It also has a chain pulley system vessel cover and storage tank which significantly eased the extraction process. In 2007 and 2008 HBTL have sold essential oil worth over USD 93,000 to the international market (Table 1).

In the very first year, the new distillation unit in Napke Yanmara has made a net profit of USD700 which was divided to the pro-poor user groups and five participating Community Forestry User Groups. Financially the figure seemed low but sale from raw material has benefitted both the local collectors, the community forests and pro-poor groups and has significantly increased the economic transaction at local level. In some instances, it was also seen that school children were also engaged in collecting wintergreen in their free time and the money earned was used to purchase books and copies for their study. They began to understand the value of local plants which were of no use to them. Earlier the MAPs are harvested unsustainably by the traders and benefit sharing was confined only to the handful of collectors.

The establishment of distillation unit has also improved local knowledge on essential oil processing technology. They were able to run distillation units independently and served as resource person in establishing new distillation units in other parts of country. This endeavor has been replicated in 16 other districts of Nepal.

Table 1. MAPs from Nepal

Name	**Altitude**	**Part used**	**Quantity of raw material ('000 Kg)**	**% yield**	**Quantity certified (Kg)**	**Quantity exported (Kg)**	**Rate USD**	**Total USD**
Wintergreen (*Gaultheria fragrantissima*)	2000	leaves	750	0.6-0.8	5000	860	24	20640
Juniper (*Juniperus communis*, *J. indica*)	3000-4000	berries and needle	200 (berries) 350 (needles)	0.8-1.0 0.7-0.8	2000 3500	- 950	- 50	- 47500
Anthopogon (*Rhododendron anthopogon*)	3000-4000	leaves	100	0.5-0.6	500	75	90	6750
Silver fir (*Abies spectabilis*)	2400 - 3600	needle	100	0.3-0.4	300	60	80	4800
Calamus (*Acorus calamus*)	700-2000	rhizome	18.75	0.8-1.0	150	-	-	-
Mugwort (*Artemisia* spp)	1000 - 2500	leaves	80	0.25-0.30	200	20	75	1500
Nepalese pepper (*Zanthoxylum armatum*)	1200-2600	berries	400	0.5-0.7	2000	25	80	2000
Total					**13650**	**1990**		**93190**

(Source: HBTL 2009)

Costly Certification

Forest and organic certification are the prerequisites for the marketing of essential oils in the international market. For the first time in Nepal, Forest Stewardship Council (FSC) has certified 6,545 ha of forest belonging to 18 community forestry in 2005 for five years. The certification was initiated by ANSAB with the financial support from USAID. This is a group certification, which is issued to Federation of Community Forestry Users Group of Nepal (FECOFUN). Likewise, for the exporting essential oil in the international market, both Chain of Custody (CoC) and organic certification have also been carried out. DMC and HBTL are FSC accredited CoC certified companies. The organic certification process was carried out with SGS India Pvt Ltd., a member group of SGS Group (*Societe Generale de Surveillance*) based in the Netherlands and certified 17 items of essential oils and 44 items of crude NWFP from the certified forests.

The cost of forest certification was around USD30,000 and FSC also charges USD3800 as annual audit fee. In 2009, the certification was reassessed. FSC reduced the certification cost to nearly USD16,000 as community forestry is more protection oriented and they had implied local auditors to reduce the management cost. For the reassessment, FECOFUN has paid around USD11,000 whereas DMC and HBTL have jointly paid USD5040 as reassessment cost for chain of custody certification. Likewise, S & D Aroma (one of the buyers) and HBTL have jointly paid around USD1300 for organic certification.

Challenges

Forest certification from international certification body is very costly. From a simple calculation, the cost of certification and annul audit is around USD50 000 which is more than 53% of total revenue generated from the trade in international market. Since initial cost of forest certification is borne by the donors, both DMC and HBTL have made sufficient profit. Even though the essential oils are FSC and organically certified, HBTL could not get any premium price in the international market. But it has opened the door for international marketing. It is still very challenging to aware all the users from community forests which include nearly 3500 HH (DMC 2006) regarding the criteria, indicators and significance of forest certification.

For the second time also, FECOFUN has managed to raise the required amount from various donors. But this is not a sustainable business practice.

Table 1 also revealed that as per the certified limit, a total of nearly 14 MT of various essential oil can be extracted but DMC and HBTL could only sell around 2 MT (which is only 15%) of various essential oil in the international market. Thus marketing should also be improved so that the cost of certification can become affordable in the subsequent business transaction.

Managing enterprise in community level is very challenging. This endeavor needs a strong networking among the forest users, community forests and District Forest Office at local level.

Conclusion

Extracting essential oil from MAP has emerged as a profitable business in Dolakha. Nepal can earn significant amount of hard currencies from extraction, value addition and export of MAPs to international communities. But even with forest, chain of custody and organic certifications, Nepal could not get premium price for the certified MAPs. The small business enterprise engaged in essential oil extraction, scattered over the vast tract of the Himalayan hills could not afford the high certification cost. National standard for certification, accredited by international certifiers, needs to be developed to reduce the cost of forest certification.

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We would like to acknowledge the efforts of all the 18 community forestry users groups, who have sustainably managed the forest in liu with FSC principle and criteria. Thanks also to Mr Parbat Gurung and Mr Khilendra Gurung from HBTL and Ramesh Lama from DMC for their inputs in finalizing this extended abstract.

ROLE OF NEEM TREE (*Azadirachta indica A. Juss*) TO SOLVE GLOBAL PROBLEM IN INDONESIA.

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Introduction

Azadirachta indica A. Juss. commonly known either as neem (Urdu), Indian lilac (English), and mimba (Indonesia), belongs to the family Meliaceae. Neem is native to all of southern hemisphere, particularly Southeast Asia including Indonesia. It grows in tropical to subtropical regions, semi to wet tropical regions, and from sea level to about 700 m elevation. National Research Council (NRC), Washington, USA had reported that "Neem: Tree for Solving Global Problem" because it has numerous utilities compare to other trees. Every part of this species has useful function that it can be converted to various products. The leaves and seeds contain some secondary metabolites such as: azadirachtin, salanin, miliantriol, nimbin, and nimbidin (Ruskin 1993). Azadirachtin contains 17 chemical components with medicinal and pesticidal functions (Rembold 1989). The functions of this tree can be divided into four categories: commercial industries (cosmetics, soap, furniture, wood material, tooth paste, protect of textile material, animal feed), as medicine (aroma therapy, cancer, dermatitis, and insect repellent), agricultural aspects (bio pesticide, fertilizers, soil conditioner), and environment (biofuel, fire wood protection, wind break, protect erosion, and used as plantation forest on degraded area/land rehabilitation).

Methodology

This study was based on direct observations of the neem industry in Bali, literature reviews, and interviews of the employer and key staff members of the company.

Results, Discussion, and Recommendations

Neem tree is a very special tree, because it is the most promising plant of all plants, that it may eventually benefit every person on this planet. Every part of this tree has function, and almost all the parts are useful (Table 1). Probably no other plant yields as many strange and had varied products except neem. We can use this species for various aspects: agriculture aspects, environment aspects, commercial industries, and as medicines. One of popular bio-pesticides comes from neem tree (Gagoup and Hayes 1984, Ermel 1995). Besides bio-pesticide, reforestation, and land protection function, it also as raw material for a number of cosmetics and medicinal products, and it has been called a multi-purpose tree (Grainge and Ahmed 1987). Neem oil has been proven effective against serious skin conditions like eczema, psoriasis, acne, dermatitis, herpes, shingles and many more. It has been shown to regulate the immune system, lower blood sugars, reduce fevers, fight gum disease, and act as a tonic for the heart. Besides, neem is one of the most valuable of all arid-zone trees, because it can tolerate extreme temperatures. The Neem tree thrives in eroded arid areas, and quickly replenishes top soil quality as its deep roots draw nutrition and moisture back to the surface of unworkable soils. It therefore has widespread applications for reforestation and erosion control.

In Indonesia, there is a non profit oriented company, named Intaran that it has been actively promoting this species in some provinces. This company produces many kinds of neem products like soap, shampoo, massage oil, fertilizer, insect repellent, bio pesticide, and soil conditioner for export. The main goals of this company are to improve the environment by planting this species at degraded and eroded areas and to increase local communities' income. This Company achieves these goals by coordinating with the Ministry of Forestry, Republic Indonesia to source good seeds, and also coordinating with local governments to involve communities in each area.

There are a number of provinces involved in this project: Bali Province, 22.5 ha (14 ha in Kutuh Village, Jimbaran Bali, 7.5 ha in Maos Village, Nusa Penida Bali); Nusa Tenggara Timur Province (118.94 ha); Nusa Tenggara Barat Province 170 ha (Plabu Village 20 ha, Buntage Village 20 ha, Gerung Village 30 ha, Gentang Village 50 ha, Prabu Village 50 ha); and South Sumatera Province (Kelapa Village, Bangka 20 ha). All of these activities involve local communities in those areas. The Company provides the seeds to the villagers, and villagers plant the seeds. After harvesting, villagers sell the products to the Company. It thus generates cash incomes for the villagers, besides contributing to protect the environment.

Table 1. Parts of neem tree and their functions

Neem tree	Shade tree, erosion protection, timber production, forestry
Seeds	Oil extraction, plant protection, raw material for producing commercial pesticides, stock protection, medicine, animal care
Oil	Soap production, raw material for producing commercial pesticides and cosmetics, plant protection, stock and textile protection, medicine, animal care, refining to edible oil, lubrication oil for engines, candle production
Neem cake	Plant protection, raw material for commercial pesticides, soil additive, fertilizer, animal fodder and hygiene
Neem husk	Neem oil extraction, mulching material, soil additive, compos/fertilizer
Fruits	Oil extraction, ripe fruits as food, medicine
Leaves	Medicine, cosmetics, mulching material, plant protection, stock protection, animal care, animal fodder, vegetables
Twigs	Feathery leaf stalk (twigs) for dental hygiene
Wood	Firewood, construction material, furniture
Bark	Toothpaste and dental hygiene, medicine, cosmetics
Roots	Medicine

According to the descriptions above, this species can empower community development by involving local communities in neem project, and improve the environment by planting it in degraded and eroded areas, and thus reduce global warming. Furthermore, neem has good prospects to be developed in other degraded areas not only in Indonesia, but also in other countries.

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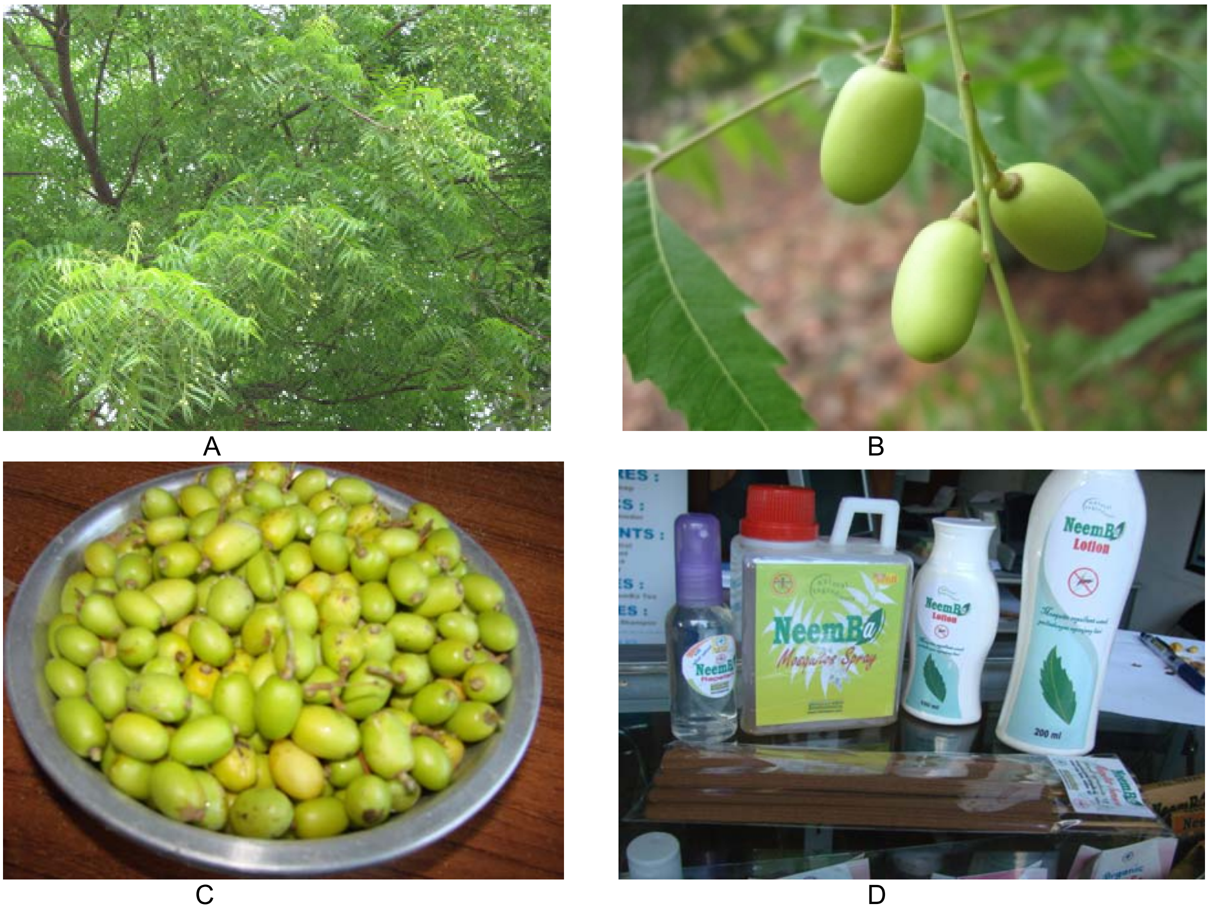

Figure 1. Neem tree (A), neem fruit (B, C), and neem products (D)

IMPROVED TAPPING OF PHILIPPINE *CANARIUM* TREES FOR MANILA ELEMI: HELPING ALLEVIATE CLIMATE CHANGE

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Introduction

The species of the family Burseraceae, e. g. pili (*Canarium ovatum* Engl.), piling liitan [*C. luzonicum* (Blume) A. Gray] and pagsahingin (*C. asperum* Benth.), are the main sources of *Canarium* resin widely known in international trade as Manila elemi. Manila elemi is utilized in the paint and varnish industries. It gives toughness and elasticity to products such as plasters, printing inks, lithographic works and perfumery. Locally, it is used in torches, starting fires for domestic use, caulking of boats and as dressing for transmission belts and conveyors. Although regarded as a minor forest product, it is a dollar earner for the country. The Philippine Forestry Statistics reported that in 2006, 180,550 kg of *Canarium* resin valued at USD 298 052 was exported to France, Germany, India and Japan. The species are now considered an important agroforestry crop especially in the Bicol Region (Figure 1). It is widely adapted to various agroclimatic conditions and a wide range of soil types. It can be grown year-round, either alone or intercropped with other crops. It is a sturdy and an excellent border and windbreak tree and also ideal for agro-tourism. Bicol Region has the biggest number of productive *Canarium* trees (72%) among the country's six regions reportedly cultivating it (Figure 2). The others are: Southern Tagalog, 9%; Western and Eastern Visayas, 18.5%; Southern Mindanao and Caraga share the remaining 1% (BAS 1996). *C. luzonicum*, the species commonly found and tapped for resin in Quezon Province are not expected to last for another 5-10 years because of unscrupulous harvesting methods by resin tappers. They deep tap, over tap and frequently re-chip, causing extensive wounds through which wood-rotting organisms can enter and colonize the trees. The trees' existence can be prolonged if tappers are educated in the biology of resin production and trained in scientific tapping techniques.

Traditional Tapping Damages

The more common *Canarium* tapping damages in the Philippines are:

- *Deep tapping* - The cuts are deliberately extended to reach the sapwood, destroying the vascular cambium responsible for the tree's continuous radial growth and healing of wounds;
- *Overtapping* - Oversized cuts or too many cuts are made around the tree circumference. The law requires that the distance between cuts around the girth should be twice the length of the tapping cut. Violations result in impaired growth and eventual death of the tree; and
- *Frequent rechipping* - This introduces impurities into the exuded resin instead of increasing the flow rate. Chips of bark, wood and foreign materials lower he resin grade. Resin must be collected at least every two weeks to give ample time for the accumulation of large, easily-removed lumps of hardened resin.

Methodology

Various R and D studies have been conducted by FPRDI including: a) determining the influence of rainfall, length of tapping cut (10 cm, 15 cm, 25 cm and 35 cm) and sulfuric acid (H_2SO_4) treatments (0%, 15%, 30% and 45%) on the exudation of resin; b) survey of faulty tapping practices of *Canarium* resin in the country; and c) studying factors affecting resin production. The investigations were designed primarily to improve the conventional methods of tapping *Canarium* trees so as to sustain productivity.

Results, Discussion and Recommendations

Proper Tapping Methods

Owing to the detrimental effects of traditional tapping methods, FPRDI laid down the following guidelines for the proper tapping of *Canarium* trees. These were based on the results of R and D studies conducted at the Institute.

1. Tap only those trees with at least 30 cm diameter at breast height.
2. Remove loose barks, dirt and other foreign bodies and lightly scrape the portion to be tapped. Start the first tapping at a point not less than 60 cm from the ground. Remember that *Canarium* species are known for their high buttresses.
3. Make a horizontal cut about 2 cm wide and 15 cm long using a razor-sharp, broad-bladed bolo or a big knife. While cutting, take utmost care to avoid damaging the cambium. A wooden mallet may be used to hammer the bolo and control the depth of cut. Other cuts may be of the same dimension as the first cut at 15 cm but the distance between the tapped portions should be about 30 cm or twice the length of the cut (Figure 3).
4. Since the resin exuded by the tree hardens slowly, a plastic receptacle should be tacked below the cut. The tapped trunk should be covered by a polyethylene sheet and sealed with plastic roofing cement. This will prevent the entry of water, insects; and debris like dried barks, leaves; and other foreign bodies, into the cuts.
5. After a week when resin exudation stops, make a fresh cut (rechipping) of 3 to 5 mm wide immediately above the previous one and at the same length.
6. Tap vertically upward on the untapped portion of the trunk and use a ladder for convenience. Tapping tools should be razor-sharp at all times to ensure clean cuts. Also, care should be taken to obtain a clean product as much as possible.

Advantages of the Technology

Tapping Philippine resins like Manila elemi is a veritable economic activity among farmers. Applying the proper or improved tapping techniques offer the following advantages:

1. prolong life of the tree;
2. increase production of quality resin;
3. increase income of tappers and the government;
4. is environment friendly and helps in the conservation programme of the government;
5. preventing the premature death of *Canarium* trees can help alleviate global climate change brought about by the increasing levels of carbon dioxide (CO_2) in the atmosphere; and
6. trees sequester CO_2 from the atmosphere and the longer the *Canarium* stands are preserved in the forest, the better they can contribute in the global effort to remedy climate change.

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Acknowledgements

Philippine Council for Agriculture, Forestry and Natural Resources Research and Development (PCARRD) for funding the project on tapping *Canarium* trees; and

International Tropical Timber Organization (ITTO) for the printing of pamphlet on Proper Techniques in Tapping *Canarium* Species (Pili Group).

Year	Quantity	Value
2006	181	298
2005	165	237
2004	144	193
2003	361	528
2002	272	482
2001	246	528
2000	377	696
1999	245	464
1998	221	448
1997	162	436

Figure 1. Production and Export of Canarium resin (Quantity in thousand kilograms, value in thousand US $, FOB)

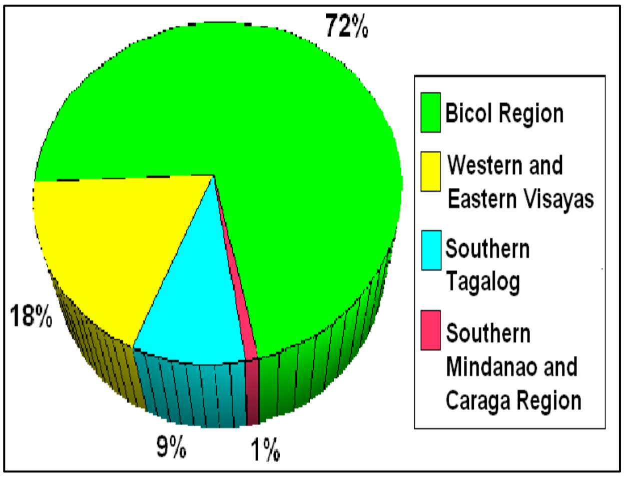

Figure 2. Distribution of Productive Canarium Trees in the Philippines

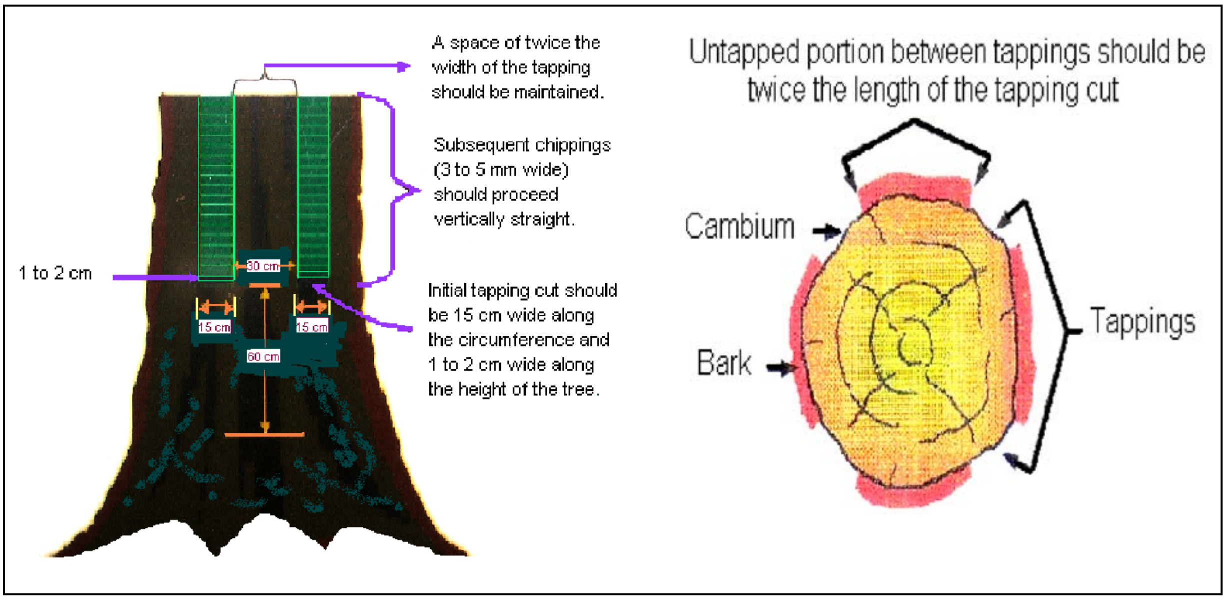

Figure 3. Diagram showing the proper methods of tapping Canarium trees

JUTE: A RAW MATERIALS FOR THE PRODUCTION OF BIOMATERIALS

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Abstract

Cellulose was extracted at a yield of 59.8 % from jute fibres by the formic acid/ peroxyformic acid process at atmospheric pressure. The amounts of dissolved lignin and hemicelluloses were determined in the spent liquor. The results showed that the spent liquor contained 10.6% total sugars, which was 76% of the total hemicelluloses, and 10.9% lignin. Microcrystalline cellulose (MCC) was further prepared from the jute cellulose by the acid hydrolysis technique. A very high yield, 48 to 52.8% (based on the jute raw material), was obtained. The acid hydrolysate of cellulose contained 2.7% glucose and 0.2% xylose. The MCC samples obtained from two different conditions, one at low acidity, the other at high acidity, were characterized by means of TGA, FTIR, XRD SEM and TEM techniques.

Introduction

Jute played a significant role in the socio-economic development in some Asian countries. For example in Bangladesh, jute and its many value-added products, played an important role in the country's economy.

The percentage of crystallinity of jute fibre (73.4 %) was considerably higher than other non-wood (52-53%) (Jahan *et al.* 2009). The higher crystallinity in jute fibre indicates its suitability in the micro-/nano-cellulose crystal (MCC/NCC) preparation. MCC/NCC can find many high value-added applications, including the production of light-weight and high-strength hybrid composites (Azizi *et al*. 2005).

The scope of the project includes: i) fractionating jute fibres into cellulose, hemicelluloses and lignin by the formic acid and peroxyformic acid treatment processes; ii) subsequently transforming the cellulose fraction into micro-crystalline cellulose (MCC) by the weak and strong acid hydrolysis; iii) characterizing the prepared MCC samples based on the FTIR, TGA, XRD, SEM and TEM techniques.

Methodology

Formic acid (FA) treatment

The jute was refluxed with formic acid in a hotplate under the following conditions:

i) 90% (v/v) formic acid concentration;
ii) 120 min reaction time at boiling temperature;
iii) Liquor to fibre ratio: 8.

At the completion of the reaction time, the fibres were filtered in a büchner funnel and washed with fresh formic acid, followed by hot distilled water.

Peroxyformic acid treatment

The formic acid treated fibres were further delignified with peroxyformic acid (PFA) at 80^{o}C. The reaction was carried out in a thermostatic water bath. PFA was prepared by mixing 90% formic acid with 4% H_2O_2. After 120 min, the fibres were filtered off and washed with a 80% formic acid solution.

Bleaching

Bleaching experiments of unbleached pulp were carried out at a 10% pulp concentration. The pH was adjusted to 11 by adding the required amount of sodium hydroxide (NaOH). The hydrogen peroxide charge was 4% (on fibre material). Other conditions were 80 ^{o}C, and 1 h. The pulp yield was determined gravimetrically.

Preparation of MCC
Fifteen grams were hydrolyzed in 375mL of 2.0N sulphuric acid at 100^{o}C for 120 min with constant agitation. The reaction mixture was allowed to cool at room temperature and filtered. The filtrate was collected for sugar analysis. The white residue obtained was washed repeatedly with distilled water, diluted ammonium hydroxide solution (5%), and more distilled water until becoming acid-free (the filtrate showed a near neutral pH). The residue was then dried in a vacuum oven to a constant weight and ground into fine powder (designated as MCC1).

The other MCC sample was produced by following a procedure by Dong *et al.* (1998), hydrolyzed with 64% w/w sulphuric acid solution for 5 h at 45 ^{o}C with constant stirring. The hydrolysis was quenched by adding a large volume of water to the reaction mixture. The resulting mixture was cooled to room temperature and centrifuged repeatedly. The residue was then dried in a vacuum oven to constant weight for 48 h and ground into fine powder (designated as MCC2).

Isolation of lignin and sugar
The lignin dissolved during the delignification with formic acid and peroxyformic acid was precipitated by adding water to the concentrated spent liquor (five times more than the volume of formic acid). The residue was filtered in a büchner funnel, and washed with water and vacuum dried over P_2O_5. The filtrate was subjected to the sugar analysis.

Results and discussion

Fibre fractionation
Shown in Table 1 are the results of jute fibre fractionation after the formic acid/peroxyformic acid/hydroxide peroxide (FA/PFA/H_2O_2) process. The cellulose fraction has very high α-cellulose (97.8%) content, indicating that hemicelluloses and lignin were effectively removed by the FA/PFA/H_2O_2 process. The cellulose yield was 59.8%. This is very high compared with other non-wood material, for example, Pan and Sano (2005) obtained 44.2% yield from wheat straw in the acetic acid process. It was reported that acetic acid and formic acid can effectively remove lignin and hemicelluloses from other lignocellulosics, such as dhaincha, wheat straw, at an atmospheric pressure (Jahan *et al.* 2007a, Jahan . 2007b, Pan and Sano 2005).

Mass balance
The total biomass recovered in the FA/PFA/H_2O_2 process was 81.3%, which is the sum of 59.8% cellulose yield, 10.6% total sugar and 10.9% lignin in the spent liquor (Table 1). This was relatively lower most likely due to: 1) some biomass such as lignin, hemicelluloses, were lost during the alkaline peroxide treatment; 2) the formation of volatile compounds such as methanol; 3) the formation of 4-O-methy glucuronic acid and other degradation products; 4) inorganic compounds dissolved from jute, which were not considered.

Table 1. FA/PFA/H_2O_2 fractionation of jute fibers

Cellulose fraction		Spent liquor	
Yield (% on original material)	α-cellulose (% on cellulose)	Total sugar (% on original material)	Lignin (% on original material)
59.8	97.8	10.6	10.9

The sugar compositions (monomeric and oligomeric) in the formic acid spent liquor are shown in Table 2. Under the employed conditions, 10.6% of the sugars of the jute can be extracted. Xylose/xylan accounted for nearly 80% of the total sugars dissolved during the treatment, while the glucose/glucan content was only 8.9 % of the total sugars in the spent liquor. Xylose/xylan can be converted into xylitol, yeast, furfural and others by chemical or enzymatic processes.

Table 2. Chemical compositions of spent liquor (% on original material)

	Arabinose	**Galactose**	**Glucose**	**Xylose**	**Mannose**	**Ramnose**	**Total**
Mono-sugars	0.12	0.32	0.15	7.50	0.20	0.11	8.40
Oligo- sugars	0.19	0.12	0.80	0.95	0.23	0	2.29
Total	0.31	0.44	0.95	8.45	0.43	0.11	10.69

Microcrystalline cellulose preparation
Microcrystalline cellulose can be prepared from the acid hydrolysis. The yields of MCC1 and MCC2 were 88.3 and 80.2% on cellulose (after the FA/PFA/H_2O_2 treatment), respectively, which is equivalent to 52.8% and 48.0% on jute. Their yields are exceptionally high, which can be attributed to the very high crystalline proportion in jute cellulose.

The sugar analysis of the acid hydrolysate was carried out based on the ion chromatographic method and the results are presented in Figure 1. In the MCC1 preparation 4.5 % glucose and xylose 0.31% were dissolved (based on cellulose), while in the MCC2 preparation 5.2 % glucose and 0.32% xylose were dissolved.

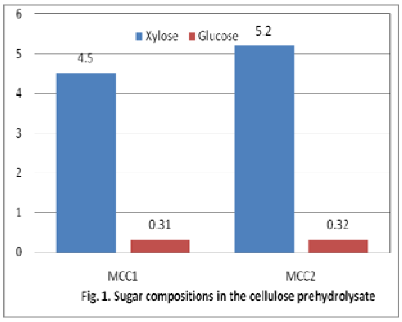

Fig. 1. Sugar compositions in the cellulose prehydrolysate

Figure 1. Sugar compositions in the cellulose prehydrolysates

Microcrystalline cellulose characterization
The dimension characteristics of the MCC samples are as shown in Table 3. The average diameters were 8.1 and 7.5 µm for MCC1 and MCC2, respectively. Shown in Figure 2 are the SEM micrograph of the MCC1 and MCC2 prepared from jute cellulose. It is evident that: 1) both MCC1 and MCC2 were well-defined fibrils; and 2) MCC2 were better separated micro-sized fibrils compared to the MCC1. The TEM results for the MCC1 and MCC2 are as shown in Figure 3. They revealed that some of MCC2 fibrils were defibrillated to nanofibers from the cell walls and the width were in the range of 15–40 nm.

Table 3. Dimension characteristics of MCC1 and MCC2

Diameter	MCC1	MCC2
Max, µm	10.1	9.8
Min, µm	5.6	4.4
Avg, µm	8.1	7.5
SD	1.35	1.82

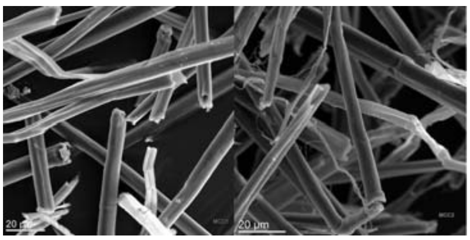

Figure 2. SEM micrograph of the MCC1 and MCC2.

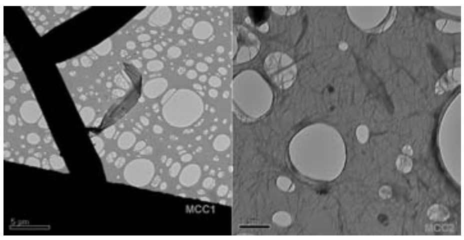

Figure 3. TEM results for the MCC1 and MCC2

Thermo Gravimetric Analysis, FTIR and X-Ray diffraction
The thermal analysis showed that the cellulose decomposition started at 315^{o}C and continued until 400^{o}C. The maximum weight loss rate was reached at 355^{o}C. At 400^{o}C almost all cellulose was pyrolyzed, and the solid residuals were relatively small (6.5 wt.%). It is seen that there were no other degradation peaks except that of cellulose, which supported the conclusion that the MCC samples prepared were very pure.

For the two MCC samples, there was an obvious absorption at 710 cm^{-1} and weak shoulder at 750cm^{-1}, which were assigned to I_{α} (triclinic) and I_{β} (monoclinic) cellulose. These results indicated that these samples were rich in I_β. The I_β proportion in the samples increased in the order of MCC2>MCC1>Cellulose.

The crystallinity index of cellulose was found to 68.7%, which increased to 74.9% for MCC2. The higher crystallinity was associated with its higher tensile strength of the MCC.

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ADAPTATION TO CLIMATE CHANGE AND NON-TIMBER FOREST PRODUCTS – AN EMPIRICAL STUDY IN WEST BENGAL, INDIA

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There are two main responses to climate change adaptation and mitigation. Adaptation to climate change refers to adjustments in natural or human systems in response to actual or expected climatic effects. The adaptation process includes three essential stages: 1) vulnerability assessment; 2) capacity building; and 3) implementation of adaptation measures. The study attempts to explain the household level adaptation to climate change and addresses the major issues of adaptation including bio-energy, water, non-timber forest products, migration, food securities, and agro-forestry and self-help groups.

Of nearly 170 million people living in and around forests in India, more than half of them are tribal and their livelihoods largely depend on non-timber forest products (NTFPs). NTFP includes fuel wood, grass, fodder, food and medicinal herbs etc are very important contributors to the well being or livelihood of villagers. The revival and further development of knowledge of the locale and management practices for sustainable production of NTFP represent an important element in the adaptation responses of forest dependent people to climate change: and domestication of high-value medicinal plants or other NTFP on farms and in-home gardens (Parrotta 2002). Moreover, Carmenza *et al.* (2005) highlighted that the promotion of agro-forestry systems as Clean Development Mechanism (CDM) projects can result in additional positive impact, including increased food security or diversification of farmer incomes through production and sale of NTFP. In India the role of NTFP in forest conservation has gained additional impetus lately with increasing emphasis on participatory models of forest conservation, such as joint forest management and community-based conservation, in which NTFP extraction constitutes an attractive economic incentive for local people (Kothari *et al.* 1997). NTFP are affected by the decrease in quantity as a consequence of climate change (Osman-Elasha and Parrotta2009). Dwindling availability of forest-produce- food, fuel, medicinal herbs, had deprived the rural poor of a supplementary source of both incomes and food. It has also been reported that NTFP are likely to be more vulnerable to changes in the climate system than to timber production (Robledo and Forner 2005).

The objective of this paper is to examine the adaptative response to the households in order to cope with the adverse effect of climate change. This paper is based on an empirical study using data collected through field survey. The study covers two villages - Kolaberia (general caste dominated village) and Kalyanpur (tribal dominated village) - located in Sonamukhi forest area in the District of Bankura of West Bengal, consisting of 65 households in 2008. Besides, this paper also examines the trends of NTFP like honey, wax, sal seed and kendu leaves in West Bengal from 1990 to 2005.

Results based on secondary data in West Bengal

(1) Honey production is declining due to climate change (Figure 1);
(2) Wax production is also declining due to climate change (Figure 2);
(3) Kendu leaves production is continuously declining trend due to climate change (Figure 3).

These declines in NTFP productions are confirmed by the household survey. As climate changes the households collect less honey, wax and kendu leaves from the forest.

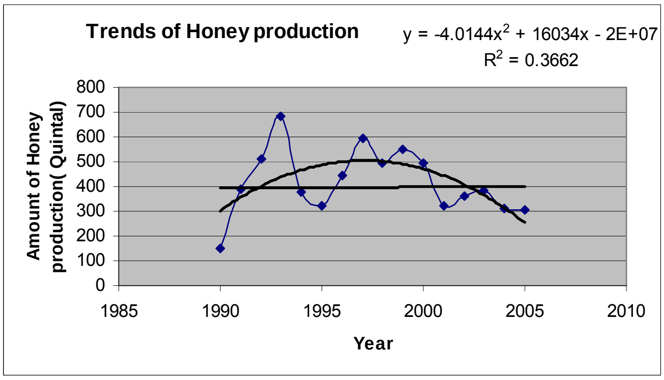

Figure 1. Production of honey over the years 1985–2005

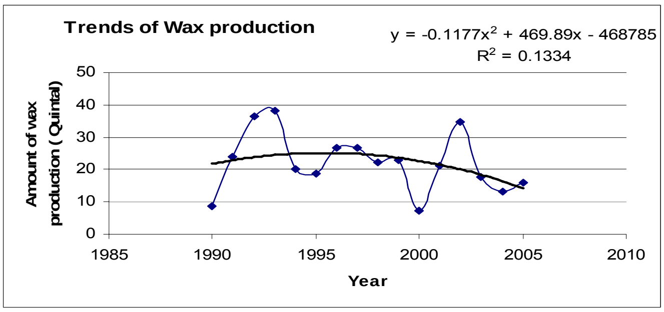

Figure 2. Production of wax over the years 1985–2005

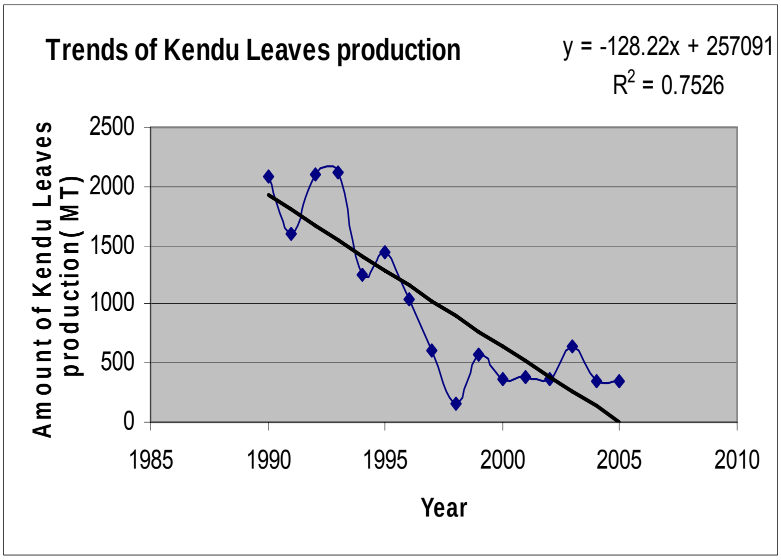

Figure 3. Production of Kendu leaves over the years 1985–2005

Results based on household survey

We asked the sample households as to how they coped with the adverse effect of climate change. They answered that use of non-timber forest products, water harvesting by means of digging and drilling for drinking water, distress migration, formation of SHGs in the micro finance program, and agro-forestry are the possible adaptation strategies.

Firstly, our study shows that at least 80% of the selected sample households use non-timber forest products as the adaptation strategy in both the villages. The non- timber forest products like fuel wood, fodder and grasses help them obtain additional cash income. On an average, a family earns $25 to $110 per year from the sale of non-timber forest products. Secondly, the problem of ground water is acute in the surveyed villages. Villagers are digging and drilling deeper for drinking water. The study indicated that more than 90% households responded that water harvesting was the important strategy for adaptation due to climate change. Thirdly, our field study also shows that migration (temporary and urban areas for work) emerged as another important adaptation strategy. About 51% and 79% of the households of the two villages say Kalaberia and Kalyanpur respectively reported that they migrate to the urban area for getting new job. Fifthly, our field study shows that more than 80% households in both villages have formed self-help groups (SHGs) for seeking loans from financial institutions such as the nationalized banks and National Bank for Agriculture and Rural Development (NABARD) for various livelihood purposes which indicate the increasing meaningful role of women in livelihoods. Sixthly, due to scarcity of food in the forest for the wild animals as the consequence of climate changes, the wild animal like elephant arrives in the locality. The arrival of elephant causes damage of crops and destruction of dwelling houses. The people drive away these wild animals using traditional weapons and devices. Lastly, we should note the important role that agro forestry can play in motivating the people to adapt to climate change, because agro forestry systems integrate food and wood production and supply many environmental and social services. We find that more than 70% households are dependent on agro-forestry for ensuring better livelihood. This paper has important policy implication for forest conservation, sustaina*ble* forest management practices, and rural development.

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BAMBOO AS GREEN MATERIAL- SAVE THE FOREST

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Abstract

Plybamboo are naturally hygroscopic in which they shrink and swell when subjected to different environmental conditions. The hygroscopicity increase due to the removal of epidermis and inner layer of the bamboo strips. One of the methods to enhance the properties of plybamboo is via impregnation with phenolic resin. The present study was undertaken to develop a process to produce high dimensionally stable plybamboo for exterior application. The phenolic resin was used to treat bamboo strips prior to being converted into plybamboo. The dimensional stability and strength properties of plybamboo improve significantly. After six months of exposure test, the strength properties of PTP decrease by about 13%; while the untreated plybamboo failed within 5 months after exposing to weather condition.

Introduction

Today, bamboo becomes more popular not only in India and China but also in Europe and America. Bamboo is regarded as a green material and is a good alternative to timber due to its fast growing and short maturity period. Commercialised products available on the market are laminated bamboo, bamboo mat, sliver board, bamboo particleboards, parquetry and plybamboo (bamboo plywood) (Zhang *et al.* 2002). Of these products, plybamboo is the most recently developed. Some applications of plybamboo include flooring, construction materials and laminated beam. However, the dimensional stability of plybamboo is relatively poor compare to that of plywood. Anwar *et al.* (2004) reported that the water absorption, thickness swelling and linear expansion (perpendicular to the grain) of plybamboo made from *Gigantochloa scortechinii* were much higher whilst the strength properties is greater than that of commercial plywood (Grade A). The present study was undertaken to improve the dimensional stability of plybamboo using phenolic resin for exterior applications.

Material and Methods

Four-year old bamboo (*Gigantochloa scortechinii*) was collected from the Forest Research Institute Malaysia (FRIM), Kepong, Selangor. The bamboo strips were impregnated with low molecular weight phenol formaldehyde (LMwPF) resin and then the dried in an oven for a few hours.. The veneers were then assembled to form 3-ply (12 mm) plybamboo and then pressed with a hot press.

Results and Discussions

Results of statistical analysis showed that the water absorption, thickness swelling and linear expansion of phenolic-treated plybamboo (PTP) were significantly lower compared to those of untreated plybamboo. The MOR, MOE and compression parallel to grain of the PTP were significantly higher compared to those of untreated plybamboo. The values were in the range between 119.4 and 80.6 Nmm^{-2} for MOR, between 15547.2 and 13767.5 Nmm^{-2} for MOE, and 41 to 60 Nmm^{-2} for compression parallel to grain, respectively. Figures 1 and 2 show the properties of plybamboo after six-month expose to weather. The results shows that after six-month exposure test, the MOR and MOE of PTP decrease by about 13% and 6% while the untreated plybamboo failed within five months of exposure. The treatment using LMwPF resin improved the performance of the products when the resin bulked in the parenchyma cells (Anwar 2008).

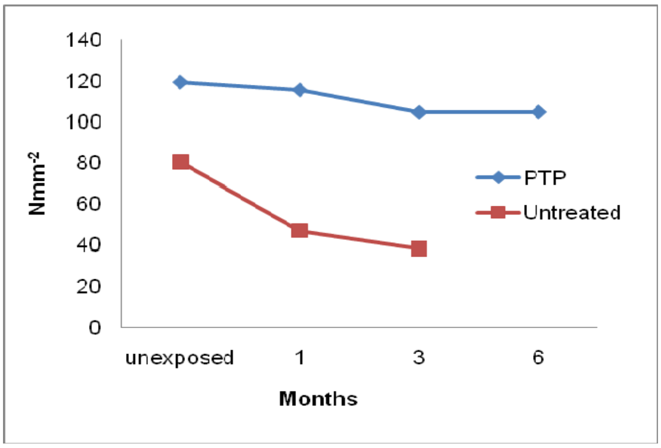

Figure 1. Modulus of rupture (MOR) of untreated and phenolic-treated plybamboo after six-month exposure test

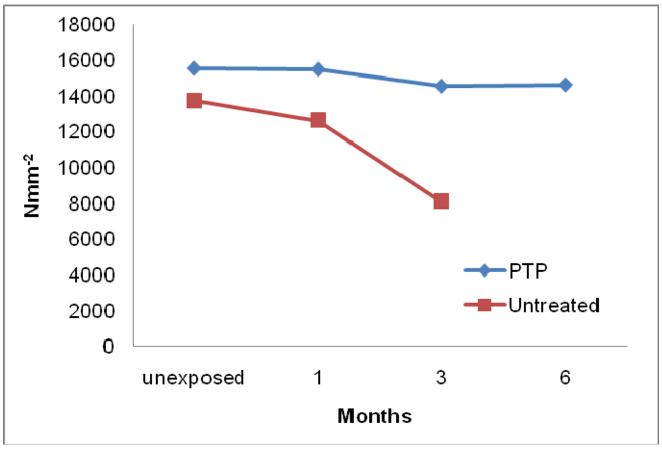

Figure 2. Modulus of elasticity (MOE) of untreated and phenolic-treated plybamboo after six-month exposure test

Conclusions

Treatment of bamboo strips with LMwPF resin followed by hot pressing at 140˚C increased the dimensional stability and strength properties of the strips. Generally, the treatment of bamboo strips with LMwPF resins were found to have a significantly improve the properties of plybamboo.

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CARBON SEQUESTRATION POTENTIAL AND USES OF *DENDROCALAMUS STRICTUS*

- A case study from Baglung District Sigana V.D. C, Nepal

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Carbon sequestration (CS) refers to the provision of long-term storage of carbon in the terrestrial biosphere, underground, or the oceans, to regulate the building up of carbon dioxide (the principal greenhouse gas) concentration in the atmosphere. But in another word, it can be defined as the removal of carbon (C) from the atmosphere by storing it in the biosphere. About two-thirds of terrestrial carbon is sequestered in the standing forests, forest under storey plants, leaves and forest debris, and in forest soils (Sedjo *et al.* 1998).

Forestry is the most important means of offsetting carbon emission for sequestrating carbon in biomass and giving positive effects on livelihood of the rural farmers because of its cost effectiveness and associated environmental and social benefits. Forestry system has more biodiversity and density of biomass than agro forestry and annual cropping systems. In Nepal, many studies have been conducted on agro forestry and agricultural crops for their benefits whereas very few studies have been done on the intangible benefits like carbon sequestration (Gautam 2002). The carbon sequestration benefits of forests can be perceived to be more important at the global than at national or local levels (Sharma 2000).

Bamboos are tall, perennial, arborescent and common grasses, which not only provide direct production benefits but also indirect environmental benefits in the form of abating global warming and climate change through conserving atmospheric CO_2. The potential carbon sequestration of *Dendrocalamus strictus* forest can contribute to setting levels of possible compensation to countries that are obliged to conserve forest beyond its own needs. Estimation of total plant biomass and soil carbon sequestered in any forest system is very important as it gives ecological and economic benefits to the local people. But this work is very much lacking in in any forest like Community Forest, Collaborative Forest Management or natural forest. There is yet any study on carbon sequestration of bamboo forest.

It is assumed that the fast growing species like *Dendrocalamus strictus* can fix the atmospheric carbon in above and below ground biomass more rapidly than those slow growing species.
However, the actual carbon sequestration potentiality of *Dendrocalamus strictus* has not so far been assessed in Nepal. But *Dendrocalamus strictus* can be found at many different elevations, and widely spread in Nepal making the assessment of total carbon sequestration potential of such forests important.

Objectives of the study

The general objective of this study was to estimate carbon sequestration by *Dendrocalamus strictus.*

The specific objectives of the study were to:

i) estimate above and below ground net carbon sequestration potential in bamboo forest system.
ii) assess the uses of bamboo in the study area
iii) estimate demand and supply of the bamboo species.

Methodology

Primary Data collection.

Sampling - Simple random sampling was carried out to collect the biophysical data of bamboo. The samples were taken randomly from the study area representing the whole area. The bamboos are measured in culms. Circular plots of radius 5.64m were laid out in the field and the area of one plot comes to be about $100m^2$. This makes it easier to calculate biomass and measure bamboo too within the plot.

Biophysical measurements **-** One bamboo from each plot was felled to measure the length and take the samples for carbon analysis.

Soil samples **-** Soil samples were taken from soil profile up to 1m depth at five different levels (0-20cm, 20-40cm, 40-60cm, 60-80cm, 80-100cm). A profile was dug at each plot.

Social survey -The household survey and key informant survey were conducted to determine demand and supply as well as to assess the uses of bamboo in the study site. There were altogether about 90 households of which about 30 household were interviewed. Focus was given to those household who had bamboo plantation in their private lands. In addition, key informant survey was also conducted to know more information about bamboo.

Data analysis
To estimate the carbon content in different parts of bamboo, the samples were oven dried at 75°C for 72 hours. They were burned in muffle furnace at 400°C and organic carbon content was calculated using relationship (Negi *et al.* 2003):
Carbon content (%) =100 - {%ash weight + molecular weight of O_2 (53 in $C_6 H_{12}O_6$}

Biomass estimation
The biomass of tree includes all parts such as stem, branch, roots, leaves and undergrowth biomass. It can be divided as above ground biomass and below ground biomass.

Estimation of Aboveground biomass - The model used was:

$$W=a + bX (D^2L)$$

Where, W is above ground oven-dried weight of bamboo culms in kg,
d is the diameter at 15 cm in cm. and
a, b are parameters estimated by Oli and Kandel (2006),

Estimation of Belowground biomass -
Rhizome biomass = 5% 0f culms biomass
BD (gm/cm3) = (oven dry weight of the soil)/ (volume of the core)
OCC was obtained by titration method.
The Walkey-Black method (Jackson 1958) was applied to measure the soil organic carbon percent. Total soil organic carbon was calculated using the formula given below (Chabbra *et al.* 2002):
SOC= Organic carbon content (%) x soil bulk density (kg/m^3) x thickness of horizon (m)

Estimation of net carbon content -
Total above ground biomass organic carbon
= {(total culms biomass x 33.27%) + ((total leaves biomass x19.54%)}
Total below ground organic carbon
= (total rhizome biomass of bamboo) x 33.27 % + total soil organic carbon.

Result and Discussion

Laboratory analysis of culms and leaves for carbon content showed 33.26% and 19.53% carbon content in culms and leaves, respectively. The above and below ground biomass carbon sequestration in bamboo was found as 1.66 t/ha and 0.08t/ha., respectively, whereas the soil carbon sequestration was found to be 230.32 t /ha.

Finally, the total carbon sequestration in bamboo forest was found to be 232.06 t/ha. The demand and supply was found to be 1600 culms per household per year and 2600 culms per household, respectively. Similarly, the bamboo was used in bioengineering, fodder, fuel wood, food, fencing, making bamboo products like doko, muda, etc., and props for house construction.

Further research on different climates, soils, localities, aspects, latitudes and elevation ranges in *Dendrocalamus strictus* forest are needed to fully assess carbon sequestration potential of bamboo forest.

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Table 1. Carbon content in different parts of *Dendrocalamus strictus*

Part	**Sample No.**	**Mean Carbon %**	**SE**
Culms	36	33.27	1.627
Leaves	12	19.54	1.129

Note SE: Standard Error

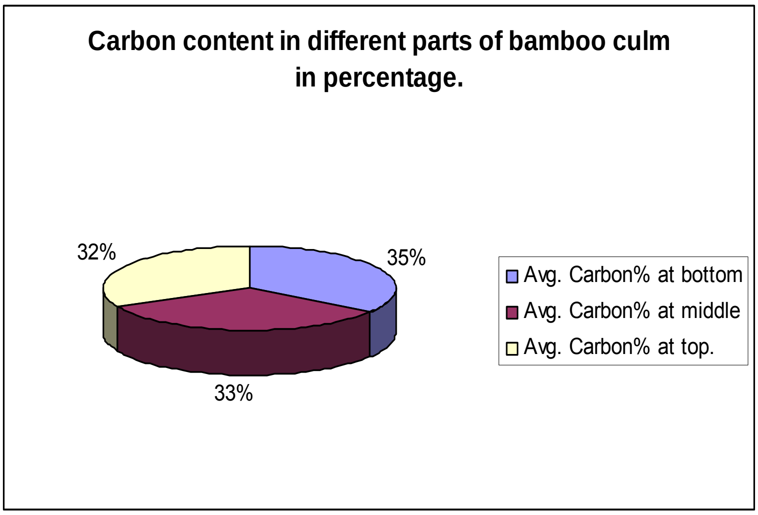

Figure 1. Carbon content in three parts of bamboo culms in percentage.

Table 2. Biomass table of bamboo

Plots	Mean biomass(t/ha)		**Total Biomass(t/ha)**
	Culms	**Leaves**	
1	5.61±0.60	0.81±0.063	6.42
2	5.58±0.51	0.81 ±0.069	6.38
3	4.17±0.57	0.6±0.078	4.77
4	4.29 ±0.36	0.63±0.045	4.92
5	3.54±0.09	0.54±0.246	4.08
6	5.46±0.81	0.78±0.105	6.24
7	4.53±0.54	0.66±0.072	5.19
8	3.72±0.48	0.54±0.060	4.26
9	4.77±0. 42	0.72±0.057	5.49
10	3.48±0.48	0.51±0.066	3.99
11	3.96±0.51	0.6±0.069	4.56
12	5.67±0.57	0.81±0.075	6.48
Mean	**4.59**	**0.69**	**5.24**

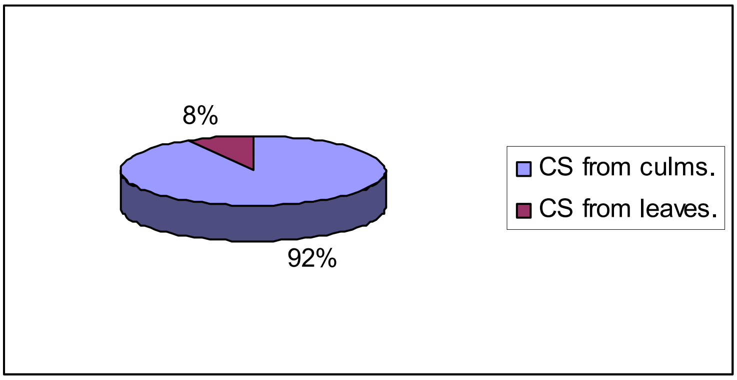

Figure 2. Total CS from bamboo parts

Table 3. Bulk density for bamboo

Depth	**No.**	**Mean BD (t/cu.m)**	**SE Mean**	**Minimum**	**Maximum**	**Range**
0-20	12	0.697	0.073	0.430	1.23	0.079
20-40	12	0.790	0.056	0.462	1.097	0.635
40-60	12	0.928	0.081	0.482	1.347	0.865
60-80	12	0.960	0.099	0.576	1.477	0.902
80-100	12	0.822	0.055	0.540	1.099	0.561

Table 4. Carbon stock in different soil profile depths of bamboo.

Depth (cm)	Sample No.	Mean Kg/m^2	SE Mean	Variance	Maximum	Minimum
0-20	12	4.479	0.295	0.954	6.633	3.091
20-40	12	4.710	0.440	2.127	6.048	2.218
40-60	12	5.001	0.681	5.095	9.562	1.913
60-80	12	4.879	0.847	7.890	10.018	1.151
80-100	12	3.966	0.637	4.457	7.875	0.324

Table 5. Carbon sequestration in aboveground biomass (culms and leaves), root and soil for bamboo

Part	Carbon Sequestration in bamboo (tonsha)
Culms carbon	1.52
Leaves carbon	0.14
Rhizome carbon	0.08
Soil carbon	230.32
Total	**232.06**

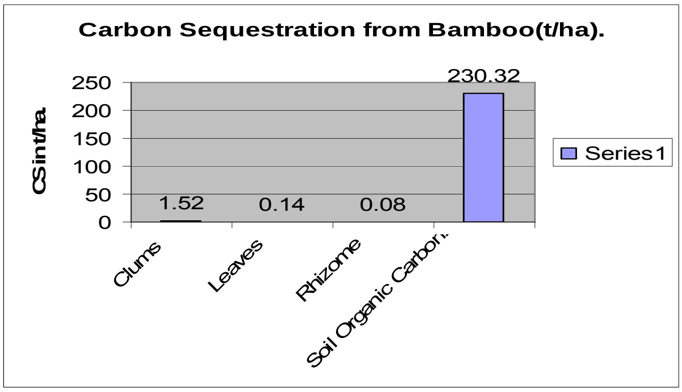

Figure 3. Total carbon sequestration from bamboo (t/ha)

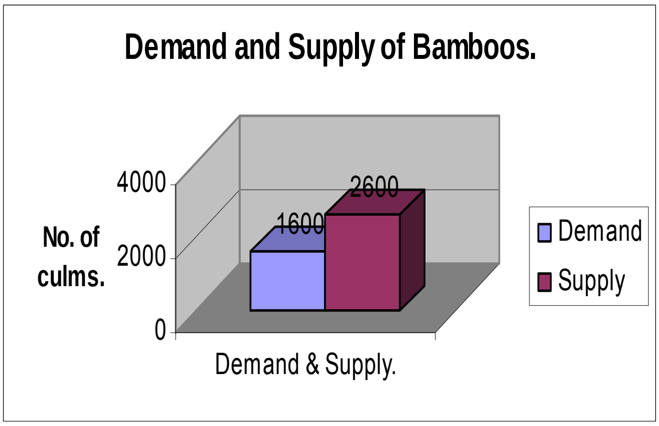

Figure 4. Demand and supply of bamboo

SOCIAL ISSUES RELATED TO JATROPHA PLANTATION AND PROCESSING AT WENSHAN PREFECTURE OF YUNNAN PROVINCE

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Introduction

China ranks second in exporting patrol behind USA, and patrol import has being inevitably increasing with the progress of China economy. It has been estimated that, China will import 250 million tonnes of patrol in the year of 2010, which is about half of the patrol demand by Chinese consumers (Wang 2009). In recent years, with increasing concern on global warming and rising energy prices, biofuel has been a top priority in China's development agenda. At the Copenhagen Conference on Climate Change in December 2009, the Chinese Delegation announced that the share of recycling energy in total energy consumption will be increased to no less than 15% of total energy consumption in China by 2020.

Currently, biodiesel is globally considered as an alternative energy source against the rising tension between economic growth and energy shortages. A biodiesel boom is moving on throughout China. As a big oil importer, China is actively encouraging the development and expansion of biodiesel industry to reduce the country's reliance on fossil fuels such as crude oil and coal. Biodiesel production from *Jatropha curcas* cultivation is regarded as an excellent potential source for renewable energy. Yunnan Province has established a 10-year goal to develop the bioenergy industry, supporting a local raw material forest base of 670,000 ha which could potentially produce approximately 2,000,000 tonnes of raw material for biodiesel each year. This paper intends to illustrate the importance of biofuel in sustaining China's growing economy, and some social and economical issues related to development of plantation of *Jatropha curcas*.

Methodology

Wenshan Prefecture was selected as a research area by occasion of a visit to evaluate *Jatropha* development project implemented by UNDP supported by a Yunnan-based mining company. Yunnan Province lies in the southwest of China and have more tropical, subtropical, temperate, and frozen zone plant species than any other province in China.

The most important data source for this study was the official files collected from the Central and Local Governments. A site visit was made to Wenshan Prefecture of Yunnan Province, during which various stakeholders, including officials in provincial, prefecture, county levels; farmers, farmers' associations, and investors were interviewed. In the community, participatory approach, along with semi-structured interviews and group discussions with local foresters, forest officials, elders in the communities, village heads and farmers, provided primary data. These combined with the secondary data were analyzed for this research.

Results

Potential of bio-energy in China's energy strategy

Bio-energy has a long history as the major energy source for Chinese livelihood and development. With the progress of industrialization and urbanization, fossil fuel has been taking more and more share of energy supply in China's society particularly in recently years. However, bio-energy still takes a substantial share of energy needs, in particular, in rural China with approximately 10-30% in overall national energy consumption, and has been declining in the past 20 years. Table 1 shows that in rural China, the total energy consumption in 2000 was about 670147 Mtce (1Mtce = 29131 ×109 MJ) , which was 44.1% of total national energy consumption in 2000 (Wang and Feng 2004). In the years between 1990 and 2005, biogas products for rural cooking amount to 2.84×107 t equivalent of standard coal (Chen 2009). In China new forms of bio-energy will be promoted, including biogas and alcohol. Based on the National Development Plan between 2006 and 2010, annual production of biogas will increase to 19 billion m^3, annual amount of electricity generated from bio-energy will be increased to 5.5 million kw, annual production of biofuel will be increased to 2 million tonnes, and annual production of biomass pellet fuel will be increased to 1 million tonnes; and by 2020, that will be increased to 60 billion m^3, 30 million kw, 10 million tonnes, and 50 million tonnes respectively (Chen 2009), and the amount of bio-energy could reach 4% of total commercial energy consumption. By 2007, production of bio-diesel reached 3 millions tonnes, and amount of alcohol production was 5 million tonnes, much ahead of the target set by above mentioned national plan.

Table 1. The energy consumption in rural area s of China in 2000 (unit: Mtce)

	Commercial energy				**Non commercial energy**			**Total**
	Coal	Fuel oil	Electricity	Total	Stalk	Firewood	Total	
For industries	175127	45155	64169	285151	--	14196	14196	300147
For residence	118101	7157	34144	160102	123160	80152	204112	370100
Total	***293128***	***53112***	***99113***	***455153***	***123160***	***95148***	***219108***	***670147***

Source: Wang and Feng (2004)

Development of biofuel in China has very significant contributions to national development strategy including energy security, environment, rural economy and social lifestyles on the macro level. It also has social and economical consequences on the ground in terms of greening mountains, water and soil protection, desertification control, biodiversity protection, job creation, rural livelihood improvement and transformation of rural economy. This paper details some selected social and economical consequences from bio-fuel development using Jatropha plantation as a case study at the Wenshan Prefecture of Yunnan Province.

Food security and rural livelihood improvement

Biodiesel production is one of the three key factors: biodiesel production in competition with food production, the increasing production costs for food, and the increasing demand, contributing to today's food crisis. Over the past decades, China has made great strides in improving agricultural productivity and alleviating hunger and poverty. However, China faces problems of energy and food shortages. The government is struggling to balance its energy strategy with grain security and thus is very cautious of developing grain-based biodiesel. As an alternative of biodiesel production with non-grain material, Jatropha as a potential source for biodiesel can be planted on barren land unsuitable for grain cultivation. It is in line with regulations on land use for biodiesel production and is unlikely to cause food crisis and security problems at both local and national levels.

Organization of Farmers

Based on the field investigation, the following issues should be addressed in development of JCL development: (1) People's forestland right should be thoroughly respected. In order to let people get benefits in JCL development, the government will be responsible for necessary pilot planting and demonstration; offering market information; attracting foreign investment; setting up JCL industry chains; organizing people; and summarizing experiences in planting organizational patterns, forestry management and benefits sharing modes. (2) People's choice should also be respected. Options in planting organizational patterns, forestry management and benefits sharing modes would be diverse, instead of mono choice, which will better fit farmer household's socioeconomic conditions. (3) By taking advantages of existing village regulations and folk constitutions in different areas, several forestry management modes will be developed, including (a) household management, (b) households cooperation management, (c) villager group management, and (d) company management.

Economical analysis

Since the JCL plantation is still in a pilot stage, an initial Cost Benefit Analysis can be calculated. Considering the fact that JCL will be planted on barren hills and lands or in open forest lands and bush lands with crown density between 0.3 and 4, the rent and output of lands are set as 0, which assumes that no benefits can be obtained from planting other species of plants on these barren hills and lands. It is also assumed that the output of JCL is 100 kg of seeds with its price 2 RMB/kg. The labor cost is 50 RMB/day. The growth cycle of JCL is 50 years. The proportion of management cost is about 20% of total output. The fund occupation cost and the government service costs such as technique testing and extending are not included in calculation.

It is estimated that by planting JCL, the unit price of forest is 615 RMB/ha/year, which will raise the employment rate by 2.06 persons per year per mu barren hill or land. The price may be further improved by introducing better seeds, increasing unit output, increasing harvesting technique and reducing labor input. Meanwhile government may have responsibility to provide allowances to farmers, since plantation of JCL may produce multi benefits in environment and employment, which will help further improve the efficiency.

Stakeholder participation

Fieldwork suggests that, generally, local farmers participating in the project tend to be from among the poorer, or at most middle-income, households of respective household types (e.g. villagers or state farm workers) based in project areas. The JCL plantation project appears to bring work opportunities and income benefits to poor households in particular, so that employment impacts are greatest on this segment of the population.

Environmental impacts

There is growing evidence that JCL may have a place in arid regions where local employment generation and restoration of degraded land are priorities. The JCL plantations can be set up on eroded lands under a wide range of climatic conditions. The plantations thus create a new forest resource and will offer a valuable alternative to logging and conversion of old-growth forests, where governance issues are sometimes a major concern. The results of a review of available literature and experiences on the environmental impacts of JCL are consistent with the expert testimonies conducted and indicate that JCL plantations will in general not affect biodiversity and water resource and water quality in the region and will be helpful for soil and water conservation.

However, introducing an alien species into the environment is not an easy consideration. The environmental implications need to be well understood. There are several concerns around the effects of such a species on the surrounding environment, especially related to biodiversity and ecological impacts on water use, soil and air qualities etc.

The JCL plantations may reduce environmental and biodiversity risks due to competition in water use, especially in the regions with lack of water resources and low water availability. The impact of pesticides and fertilizers on soil and air qualities are largely a matter of rigorous and disciplined management and standard in plantation operations. JCL is able to “pump” minerals from the depth of the soil to the surface since it has a deep reaching taproot, leading to a rehabilitation of degraded land. The press cake which remains after oil extraction by the expellers is a very good organic fertilizer with great value, which can meliorate the soils. Therefore, water use of JCL plantation in Wenshan should be examined on scientific level to justify the environmental benefits.

Recommendation

Being an essential part of China's alternate energy strategy, the development of forest biodiesel offers a win-win solution in benefiting the growth of the industry and protection of ecological environment. Present opportunity faced in China on JCl development are of great potential, including availability of barren mountains and alternative land for plantation, potential contribution to livelihood improvement, regional economic development. There are a numbers of great challenges facing in China for development JCL plantation and processing, which included: food security, biodiversity, land competition, water balance, community participation, company-farmer cooperation, production chain development, and potential negative effects on the eco-environment. Development of JCl plantation also need to considered the issues of on-going process of collective forestry tenure reform, including fragmentation of forest land, unification of farmers association, extension system.

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FUELWOOD EMISSION AND CO_2 MITIGATION STRATEGY: A CASE STUDY OF WESTERN HIMALAYAS OF INDIA

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Abstract

Poor dependence on forest for goods and services since generation leads to forest degradation and changes in atmosphere. This has by now reached to the level from which the corrective measure for safeguarding the atmosphere is becoming beyond repair. Fuelwood extraction from natural forests is one of the important agents for this situation. The extraction from forests leads to biomass destruction and burning degrades atmosphere through addition of pollutants, which, therefore vital for climate perspective.

This study addresses the emission pattern and the mitigation strategy by conducting a comprehensive survey of randomly selected 102 rural hilly households of Western Himalayas, Uttarakhand, India at altitude of 1100–1800 m by measuring concentration of pollutant gases released during fuelwood combustion in kitchen by portable instruments.

The average fuelwood consumption was 8.51 kg/day by a household. Therefore, the total of 2.7 mt biomass is removed annually from the Uttarakhand forest for fuelwood combustion as 865 411 households use fuelwood for cooking as per census 2001. However the burning of fuelwood leads emission with mean ratio for CO, SOx and NOx of 8.43, 0.21 and 0.23, respectively. This is estimated to be 3.87 mt of CO_2 emissions on annual basis in the region by the households.

Therefore the mitigation strategy revolves around the reduction of emission by utilising proper alternatives. The shifting to clean fuel may be one of them besides technological interventions such as improved stoves, biomass cogeneration plants etc. The cost of shifting to expensive clean fuel alternatives such as LPG (at Rs. 400) requires the total expenditure of Rs 8307 million for all households of the region. On comparative basis this cost is similar to the total mitigation cost of CO_2 emitted due to the burning of fuelwood with cost of US $3–5 per tonne. However, the burning leads to several other hazards such as hardships, health etc. This may however conclude that the shifting to clean fuel will not only mitigate the atmospheric burden of carbon rather improve quality of life of the poor.

Introduction

In the biosphere, atmospheric gases are being produced by various natural, biological and man made processes. These include photosynthesis, respiration-decay, nitrification, dentrification, methanogenesis, industrialization, forest fire, biomass burning, etc. Out of these, biomass burning, which include the forest fires and burning for household energy, is recognized as a significant global source of emissions, and contribute 40% of gross carbon dioxide and 38% of troposphere ozone (Huggett 1995). It has a significant impact on global atmospheric chemistry, primarily in the tropics (Crutzen *et al.* 1979; Logan *et al.* 1981). Third Assessment Report of the Intergovernmental Panel on Climate Change, also reported the situation and estimated the increase in concentration of GHG in the atmosphere for CO_2 by 29 %, CH_4 by 150 % and N_2O by 15 % in the last 100 years, which has act for rising of the mean surface temperature by 0.4 - 0.8^0C globally (Climate Change 2001).

The use of fuelwood, charcoal and non-woody biofuels for various household needs is a daily event for about half of the world's population, mostly in the developing world (Ludwig *et al.* 2003). This burning has significant negative impacts on indoor air quality and on the surrounding climate. This exposure is considered to be responsible for 1.5-2 million deaths per year, in developing countries (Bruce *et al*. 2000, WHO 2002, 2003). Global biomass burning is more extensive now-a-days and appears to be increasing with time (Levine 1990). The emissions from the burning of fuelwood may have increased by about 50% since 1850 and tropospheric concentrations of CO_2, CO, CH_4, non-methane hydrocarbons and ozone are increasing with time (Levine 1990). In addition to carbon dioxide emissions, wood burning also creates the products of incomplete combustion (PICs) which have a global warming potential equivalent to carbon dioxide (Smith *et al.* 1992). The fuelwood burning accounts for 1430 Tg annually in the rural areas of developing countries and results into the release of 640 Tg of carbon into atmosphere annually.

Earlier estimates of global biomass burning were based on simple quantitative descriptions and generalizations due to lack of proper data. Moreover, lack of technological advancements coupled with lack of experimentation for measuring the GHG was the main reason. Moreover, since many factors such as geoclimatic conditions, vegetation distribution (species and types), farming methods and population densities influence the biomass burning together with its varied intensities, therefore simple global characterizations of these burning practices cannot provide reliable estimates (Yevich and Logan 2003). Besides this, the choice of biofuel consumed depends on availability, local customs and season (Meyers and Leach 1989). Thus, the localized estimates may improve the precision and reliability of the estimates. Moreover, reliability of estimates of trace gas emissions from biomass burning depend not only on proper estimates of the amount of matter burned, but also on precise estimates of emission factors from burning of household fuels together with comprehensive assessments of the conditions of domestic fuel use throughout the developing world (Yevich and Logan 2003).

In India, rural population depends on traditional biomass fuels for meeting their household energy needs, 68.3 million tones of carbon released annually due to biomass burning and fuelwood accounts for 82.3% (Kaul 1993). The monthly consumption of fuelwood has increased per person from 16.24 kg in 1987-88 to 17.27 kg in 1993-94 (NSSO 1997).

This dependency of poor on forest for goods and services since generation leads to forest degradation and changes in atmosphere. This has by now reached to the level from which the corrective measure for safeguarding the atmosphere is becoming beyond repair. These extraction from forests leads to biomass destruction and burning degrades atmosphere through addition of pollutants, which, therefore vital for climate perspective. Therefore, we tried to propose the changes for shift to clean fuel from the fuelwood through scientific analysis of released emissions with its economics for policy makers.

Methodology

The present work is based on a comprehensive survey through pretested questionnaire conducted in the rural hilly tribal areas of Dehradun districts of Uttarakhand, India. It lies between latitudes of $30^{\circ}31'$ and $31^{\circ}03'30''$ N and longitudes of $77^{\circ}45'$ and $78^{\circ}07'20''$ E with spread of 1002.07 sq km at the altitude of 1100–1800 m. Individual households were approached and information pertaining to the relevant parameters of fuelwood burning was collected from 102 household selected at random from different villages.

The carbon dioxide measurement of fuel-wood burn emission was recorded by calibrated portable instruments from the kitchens of each selected households during and before chulha i.e. local stoves burning. The calibrated Gas Alert Micro 5-IR was used to measure concentration of CO_2 and CO, however Q-ARE Plus Multi-Gas Analyzer was used for NO_x and SO_x. Multiple measurements of the concentration of gases at 10, 30 and 60 minutes time scales were taken after burning of stoves besides the initial status of the gases i.e. before burning of stoves. These measurements are considered as the indices of exposure. The first exposure is personal exposure to hazardous gases while cooking (first 10 minutes), second (first 30 minutes) and third (first 60 minutes) is for others through measuring it in kitchens as a surrogate for personal exposure to others keeping in view of dispensation in the nearby atmosphere.

The emission ratio (ER) has been estimated for all considered gases. This is the excess gas production (above background) normalized with respect to the excess CO_2 production (above background). It is defined as below:

$$ER = \frac{\Delta X}{\Delta CO_2}$$

Where ΔX is the concentration of the gas X produced by fuelwood combustion in addition, $\Delta X = X^* - X$, where X^* is the measured concentration of X in the biomass burn smoke and X is the back ground concentration (initial) of the species; and $\Delta CO_2 = CO_2^* - CO_2$, where CO_2^* is the measured concentration in smoke and CO_2 is the background atmospheric concentration (initial) of CO_2 (Levine 1994). The emission factor (EF) is the quantity of pollutant gases emitted per unit of activity. The emission factors of trace gases from biomass combustion are influenced by several factors including the actual amount of carbon in the pre-burned dry matter, the size, shape and moisture content of the sample, and the flaming versus smouldering pattern of the burning process (Ward *et al.* 1996).

Result and discussion

***Household characteristics*:** The household of the region generally lived in kachha house (side walls made of wooden planks and roof made of slate) with an average family size of nine members. Majority of these were illiterate farmers by profession with an average of 0.46 ha of irrigated land with (Table 1). Their livelihood depends on primarily agriculture and forests. They collect forest products for a wide range of uses. Besides this they also involved labour activities though intermittently. Their average monthly household income was less than $ 80 (at $1 = Rs. 50) for the family of nine members. Fuel wood is primary source of cooking energy for all households. Though the geographical area supports good forests, however, in some cases people have to travel long distance for fuel wood collection and spend considerable amount of time for the fuelwood collection (Table 1). They collect approximately 18 kg of fuelwood in each alternate day for cooking and other purposes such as heating of water and rooms besides twigs for composting. In general, fuelwood collection was primarily women's responsibility (Pandey 2007). This all together confirms the poor quality of life of the community.

Table 1. Descriptive statistics of quality of life

Parameters	**Mean ± SE**	**Min.**	**Max.**
Family size	9.37 ± 0.29	5	30
Total land holding (in Ha)	3.46 ± 0.54	0.25	15
Irrigated land (in Ha)	0.46 ± 0.21	0	7
Monthly income per household (Rs)	3984.80 ± 567.00	500	20000
Monthly Expenditure per household (Rs)	3726.10 ± 509.30	800	20000
Education of head of house (Year)	4.61 ± 0.69	0	17
No. of Rooms in a house	1.24 ± 0.11	1	12
Age of head of house (Year)	44.72± 2.02	25	70
Fuel wood collected at a time (kg)	18.26 ±1.81	6	65
Time spent for fuel wood collection (Hours)	4.33 ± 0.26	1	8
Distance travelled for Collection (Km)	3.11 ± 0.14	1	4

***Kitchen and Cooking Parameters*:** The location of kitchen generally depends on the size of house and family status as revealed by the respondents. Generally kitchens were made of wood with small in sizes and lacks proper ventilation devices with average volume of generally 448 cm^3. Kitchen was also used for dinning space in most of households. Only 20% kitchen has small window for ventilation and lighting purposes. Only 15% stoves have chimneys for smoke emission and 50% has small openings on side walls. In most of the kitchens, the ventilation is being taking place from the doors due to absence of ventilator structures. The cooking was women's responsibility, who were back bone of the family. The chief cook and their associates were in general young women up to age 40 to 50. In this area, cooking practices is generally conventional. The fires for cooking are prepared inside the kitchen. The fire device was locally made at house and an erased structure on the floor made of mud and locally available materials with either in L or line shaped having one to five burners. There is generally an erected point of mud on the mouth of the burner for keeping pots. The kitchen was in general not spacious, and may be classified into four types based on the location of stoves in the house. Twenty seven percent kitchens were indoor with partition and 25% without partition, however another 27% kitchens was outside and attached to the house and the rest 21% were separate kitchen outside the house. The entry point, the door, acts more aptly as ventilator in absence of proper ventilator.

The amount of smoke emitted during combustion depends upon the quantity of fuel burned and the time span of combustion. The average time of stoves burning was 5.6 hours a day which accounts for the combustion of near about 8.51 kg wood fuel per day. They cook 2 to 3 meals per day depending on the requirements and their engagements for livelihood activities. In general, the cooking process were started at early in morning between 4.30 am to 5.30 am in morning session and at 4.00 to 5.00 pm in evening session depending on the requirements of the households with the initial load of 1 to 2 kg followed by two to three reloads combined with fanning or blowing. Depending on the desired effect, the fire was being controlled by the reloading or removal of burning fuel and fanning or blowing. Exhaust gases were released into the kitchen, which was in general ventilated through the doorways, the windows, and a small hole at the roof above the stoves. During the initial phase, concentrated smokes were being released, which turns into the flaming in due course of time.

Table 2. Descriptive statistics of kitchen and cooking parameters

Parameters	Mean ± SE	Min.	Max.
Stoves burning in morning (Hours)	1.82 ± 0.16	1	5
Stoves burning in evening (Hours)	2.37 ± 0.14	1	7
Stoves burning in mid day (Hours)	0.79 ± 0.15	0	3
Stoves burning in one day (Hours)	5.65 ± 0.24	2	12
Time for Smoke emission morning (Min)	12.02 ± 0.98	3	30
Time for Smoke emission evening (Min)	11.91 ± 0.91	3	30
Time for Smoke emission mid day (Min)	4.46 ± 1.00	0	25
Number of pot in a stoves	2.78 ± 0.09	1	5
Cooking frequency per day (No. of Meals per day)	2.22 ± 0.04	2	3
Chief cook's age	39.30 ± 1.73	20	62
Regular Associate cook' s age	27.34 ± 1.83	14	32
No. of doors in kitchen	1.25 ± 0.05	1	3
No. of ventilations	1.43 ± 0.08	0	6
No. of chimneys	0.11 ± 0.03	0	1
No. of windows	0.30 ± 0.73	0	3
Kitchen Volume (cm^3)	448.34 ± 35.67	36	1890
Fuelwood required per day (Kg)	8.51 ± 0.35	3	20

GHGs Emission**:** Mean value of surrounding concentration in milieu was also found near to exceeding the critical mean value mentioned in the standards for residential area in case of NO_x and $SO_{x,}$ which accounted for 0.13 and 0.25 ppm for one hour mean respectively against the standard for residential area by Ambient Air Quality Standards, 2004. It was probably due to excessive combustion of fuel wood for a considerable amount of time within closed poorly ventilated kitchens besides the nature of fuelwood coupled with moisture content. While mean value of CO_2 for one hour mean for background environment was measured as 264.22 ppm meets the standard mean value. However, the concentration of GHG and CO after one hour varies with respect to kitchen. Temperature inside kitchen ranges between 20.0 to 35.0^0 C during combustion of fuelwood which is higher up to 1 to 2^0 C than outside, however humidity ranges between 88 to 45 percent which is lower upto 7 to 16 percent than outside. It was also observed that with time there is increase in temperature which causes depreciation in humidity (Table 3). The concentration of CO_2, CO, SO_x and NO_x are reported as well as the temperature and humidity inside the kitchens in Table 3. The background value of CO_2 before the combustion was below 600 ppm except in one case, where it was 1050 ppm. Probably, it was due to the continuous burning of fuelwood in kitchen with no ventilation. The temperature and humidity showed that it has sharp increase with the initial phase of burning and stabilizes with time. It is obvious too. However, in between also, sudden increase was noted just after reloading. These all emitted gases disbursed to the atmosphere and mixed with the atmospheric gases and contribute for increase in concentration of these gases.

Table 3. Temporal behaviour of CO_2; temperature and humidity in Kitchens before and after fuelwood combustion

Gas/Items	Mean ± SE			
	Before Combustion	After Combustion		
		10 Minutes	30 Minutes	60 Minutes
CO_2	264.22 ± 174.11	1089.71 ± 711.41	1329.22 ± 814.71	1246.38 ± 814.71
CO	2.42 ± 3.35	53.04 ± 29.71	67.18 ± 29.84	66.15 ± 31.88
SO_2	0.13 ± 0.15	1.61 ± 1.77	1.63 ± 1.47	1.88 ± 1.88
NO_2	0.25 ± 0.20	2.22 ± 2.22	2.13 ± 1.05	2.11 ± 1.12
Temperature	28.33 ± 3.79	29.7 ± 2.82	29.83 ± 2.139	30.82 ± 2.49
Humidity	66.16 ± 8.88	64.09 ± 9.09	60.89 ± 8.09	60.89 ± 7.54

The mean concentration for CO_2 was observed 1246.38 ppm. The CO concentration ranges from 4.30 ppm to 127.80 ppm. The NO_x concentration varies from 0.10 to 4.00 ppm with mean 2.11 ppm and SO_x varies from 0.1 to 10.70 ppm with mean 1.88 ppm (Table 3). The variations in these gases were attributed due to the phases range from flaming to smouldering and vice versa. These all are probably due to the condition of fuelwood used for fire, species, and environmental conditions including the wind speed and directions.

Carbon mass balance is used to derive the emission factor for CO_2 and used for estimates of emission ratios of other compounds relative to CO_2 for their corresponding emission factors. The carbon content in biofuel and ash is about 50% (Susott *et al.* 1996) and 11% (Brocard *et al.* 1996; Brocard and Lacaux 1998). The averages proportion of ash is 6.6 ± 2.8% for wood weight relative to the burned fuel (Ludwig *et. al.* 2003). The remaining carbon of the initial fuel is released to the atmosphere. An exact calculation of emission factors requires the knowledge of all carbon compounds released due to the combustion of the fuelwood and particulate matter. However, as carbon emissions consist predominantly of CO_2, therefore the approximation that is made by calculating emission factors will not introduce any significant error as also supported by Brocard *et al.* (1996) and Brocard and Lacaux (1998).

Based on the periodic measurements, the emission ratio of CO, SO_2 and NO_2 was estimated to be 8.56, 0.21 and 0.20 percent for one hour burning with the mean ratio of 8.43, 0.21 and 0.23 percent respectively during the burning. The mean CO_2 normalized ERs for these pollutant gases was 8.0, 0.17 and 0.23 respectively.

The average moisture content of 20% mcdb (moisture content on dry basis) was considered, as suggested by Leach and Gowen (1987) and Hall *et al.* (1994). The emission factor (EF) for CO_2 was calculated based on the dry wood weight basis. Therefore, weight of dry fuelwood was 800g against one kilogram of green fuelwood and only 50% of this will be carbon, therefore the carbon content was 400 g. The carbon in ash was 6 g, which remains into ash. Therefore, the remaining carbon in the initial fuel will be released into atmosphere. The total carbon was 394 g (emission factor of CO_2) from one kg of fuel wood. The EF for CO will be product of normalized emission ratio multiplied by total carbon content, which is 32 (80 x 394/1000). The EF for NO_2 is 0.90 (2.30 x 394/1000) and for SO_2 is 0.67 (1.70 x 394/1000).

Concurrent to the emission measurements, the biofuel consumption rates and patterns in rural hilly locations of Uttarakhand, India were also estimated. Therefore, for Uttarakhand state, assuming the per capita fuelwood consumption rate 8.51 kg (n = 102) for the whole rural hilly population, the annual consumption of fuelwood in Uttarakhand will be 2 688 096 378 kg (8.51 x 365 x 865 411). The Census (2001) reported that the number of households using fuelwood in Uttarakhand is 865 411 with 807,913 households from rural area and 57,498 from urban area. Therefore total carbon content emitted from rural and urban area of Uttarakhand on annual basis is 2 688 096 378 x 0.394 = 1,059,109,973 kg (1.06 Tg CO_2-C yr^{-1}). The total NO_2, CO and SO_2 content emitted from these areas are 2 419 286.74 kg, 86 019 084.1 kg and 1 801 024.573 kg respectively. This is estimated to be 3.87 mt of CO_2 emissions on annual basis in the region by the households. Economics of this CO_2 emission on annual basis due to fuelwood burning at household levels ranges from Rs 534 million to Rs 890 million at $3–5 per tonne CO_2 for the SFU's dependent households of Uttarakhand.

Therefore the mitigation strategy revolves around the reduction of emission by utilising proper alternatives. The shifting to clean fuel may be one of them besides technological interventions such as improved stoves, biomass cogeneration plants etc. The cost of shifting to expensive clean fuel alternatives such as LPG (at Rs. 400 including the rate of transportation to these hilly locations) requires the total expenditure of Rs 8307 million for all households of the region with the consumption rate of two cylinders per household per month. This leads to use of total 0.295 mt LPG and therefore release of 0.885 mt CO_2 with conservative approximation of release of 3 tons CO_2 due to burning of 1 ton of LPG. This further add the cost of CO_2 emission on annual basis due to LPG burning at household levels ranges from Rs 1.20 million to Rs 2.10 million at $3–5 per tonne CO_2. Therefore the net total cost incurred for shift will be Rs 8310 million.

This shifting cost will not be more in comparison to the fuelwood burning economics, which is of nearly same with consideration of only CO_2 removal against the fuelwood use. However, the shifting cost will be much lower if one include all other externalities generated due to fuelwood such as health hazards, ecosystem loss etc. therefore, it may be concluded that the shifting to clean fuel will not only mitigate the atmospheric burden of carbon rather improve quality of life of the poor.

Conclusion

The study clearly reflects that these poor, who has poor quality of life due to remote location has been burdened doubled due to use of fuelwood. The fuelwood use was mainly due to their deprivation of clean energy i.e. energy poverty. More than these, the use of fuelwood is also responsible for several health hazards. In the same location, the disease burden for Acute Lower Respiratory Infections (ALRI), Chronic Obstructive Pulmonary Diseases (COPD) and lung cancer was estimated to two and three times higher for Disability-adjusted life years (DALYs lost) and Deaths for the forest dependent communities, respectively compared to national burden of disease. Moreover, ALRI is one major contributor to disease burden for these communities (Pandey 2009). Under these circumstances, the shift from fuelwood to clean fuel, i.e. LPG, may be a way to improve better quality of life of these poor. However, they showed their unwillingness to shift mainly due to lack of sustainability, and also free availability of fuelwood in the forests. However, those who are relatively better off, who has experienced the change, welcome the shift with assurance of regular supply of LPG and some sustained means of livelihood. Improved wood based cooking technology has not impacted much (Kandpal *et al.* 1995).

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CULTIVATION OF JATROPHA TO MITIGATE CLIMATE CHANGE IMPACTS IN INDIA: AN ANALYSIS

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Introduction

Cultivation of *Jatropha* seed for biofuel production is a relatively new concept in India. Indian Government is promoting *Jatropha Curcus* to reduce dependence on crude oil and to achieve energy independence by the year 2012 under the National Biodiesel Mission. The concerns of global climate change and energy security are forcing the world to look for its long-term replacement. It is in this context that bioenergy is becoming increasingly relevant as a possible and potential alternative to fossil fuels. (Raju *et al*. 2009).

Bioenergy is defined as the energy generated through biofuels that are produced from renewable sources of plant origin (Rao and Bantilan 2007). The Government of India has identified 400,000 sq km of land where *Jatropha* can be grown, hoping it will replace 20% of India's diesel consumption by 2011. So far, nearly 50,000 ha of land in the country is under *Jatropha* cultivation (Gopinathan and Sudhakaran 2009). Currently India's biofuel production accounts for only 1% of global production (Licht 2009). Unlike other countries, India is not using vegetable oils derived from rapeseed, mustard or oil palm for the production of biofuels. This is because India is not self-sufficient in edible oil production and depends upon large quantities of imports of palm oil and other vegetable oils to meet the domestic demand. Around 40% of the total requirement of the country is today met through imports (Raju *et al* 2009). India accounts for 9.3% of world oilseed production. It has the world's fourth largest edible oil economy. Biofuels are generally considered as offering many priorities, including sustainability, reduction of greenhouse gas emissions, regional development, social structure, agriculture and security of energy supply (Reijinders 2006). The greening of wastelands and regeneration of degraded forest lands through cultivation of biofuel crops is another added advantage (Mandal and Mithra 2004).

Jatropha curcas is a multi-purpose non-edible oil-yielding perennial shrub originated in tropical America and West Asia. This plant can thrive on any kind of soil, can endure long periods of droughts and need minimal inputs or management. Once fully matured, it can produce seed for 30 to 35 years. The seed contains 30 to 40% of oil. Beside this, its latex are used for medicine, its bark has a dark blue dying agent used for colouring clothes and leaves are used as food for the tusser silkworm. It has deep root system which stops ground erosion and increases water storage in the soil. It can also sequester lots of carbon dioxide from the atmosphere and stores it in the woody tissues and assists in the build-up of soil carbon. The two by-products of biodiesel are oil cake and glycerin, both of which have huge market potential. *Jatropha* oil cake is rich in nitrogen and is an excellent source of plant nutrients and a rich raw material for composting.

Methodology

This paper analyses how suitable is this crop to mitigate climate change in the long run by gathering data through reviewing government reports and documents. It is a new concept for simultaneous wasteland reclamation, fuel production and socio-economic development in degraded areas in India. Can it really sustain village communities to eradicate poverty which is the big hindrance for India's economic development? To meet its growing population India needs to increase food production by 50% in the next 20 years. Is it possible to utilize only the wastelands for its cultivation without compromising the food security of the country?

Major Findings

At present *Jatropha* cannot be used as a biofuel to mitigate climate change impacts. Though there are many advantages in introducing it in rural India, but there are many drawbacks as well. There are uncertainties over the yield of oil, for which sufficient field data is not yet available; and the financial viability of the biofuel is also yet to be proven. For many, biofuel are still relatively unknown (Raju *et al.* 2009). There is lack of confidence in farmers due to non-declaration of the biofuel policy by the state governments, though there is a biofuel policy at national level. There is no clear cut declaration of minimum support price by some competent authority. Non-availability of certified seed or other growing materials, lack of marketing facilities and micro-loans by the Regional Rural Banks in India for plantation/processing are also the major obstacles in introducing this biofuel.

In India, nearly 70% of the population live in rural areas and depend on agricultural and related activities for their livelihood. Moreover, in rural India, around 28% people are still below poverty line. Food security continues to be a priority for the Indian Government in all its development efforts (Bamji 2007). The availability of land is an important requirement for the large-scale national biofuel programme. The present strategy of the central government is to utilize wastelands for biofuel plantations so as not to affect the food security of the country. Biofuel plantation on wastelands mainly depends on two factors: availability of wastelands and suitability of different agro-ecological regions for biofuel plantations (Government of India 2003). *Jatropha* plantation should not encroach upon farmer's other wasteland, needed for multiple cropping in near future. If however used, the farmer should be given proper compensation. Developed nations are promoting the usage of biofuels, a way to check the global warming by using edible oil seed. Developing countries who imports edible oilseeds from them should be aware of this. It should not affect the quantity of their imports.

The most welcoming factor behind *Jatropha* biofuel production is creating employment opportunities for rural poor. Local institutions like Joint Forest Management Committees, Self-Help Groups and Local Self Governments can play an important role in involving village communities in biofuel programmes. Locally produced biofuel can be used for rural electrification, operating irrigation pump sets and other minor works.

Recommendations

There should be proper selection of high yielding and high oil content varieties of seeds. Arrangement of large-scale supply of planting materials should be done. There should be development of location specific agro-techniques and providing agronomic support through contract farming. Pilot scale trials should be considered at different locations to demonstrate economics of cultivation and updating of location specific production technologies. Commercialization of potential byproducts like glycerin, oil cake as organic fertilizers and pest repellent, blue dye from leaves twigs and barks, and explore the possibilities of taking more inter crops. Liberal financial support to Non Governmental Organizations/different governmental departments for trainings and awareness campaign is another important factor that could ensure success of the programme.

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Appendix I

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The KFRI was the sole sponsor of this workshop. Every year KFRI makes significant financial contribution to IUFRO, and a portion of this contribution is allocated to APAFRI for organizing forestry activities in the Asia Pacific region. This is the third workshop that APAFRI had organized utilizing this allocation. In 2007, APAFRI with partners organized an international conference on forest-related traditional knowledge in Kunming, China; and in 2008 the allocation was utilized for the Asia and the Pacific Forest Health Workshop – Forest Health in a Changing World, in Kuala Lumpur.

Many individuals had contributed to the success of this workshop. Dave Cown (New Zealand) and Park JungHwan (KFRI), with their numerous valuable ideas, had assisted in the organizing of this workshop from the very beginning. Dave Cown had also assisted in reviewing the abstracts and selection of presenters. Anura Sathurusinghe (Forest department Sri Lanka) and his team handled all the logistics of organizing this workshop.

Appendix II

WORKSHOP PROGRAMME

Day 1	***14 December 2009***

08:00 *Registration*

09:00 – 10:00 *Opening*

- Address by Korea Forest Research Institute
- Address by IUFRO
- Address by APAFRI
- Opening by FD Sri Lanka

10:00 – 10:30 *Coffee Break*

10:30 – 12:30 *Keynotes* (Chair: *Anura Sathurusinghe*)

- Green Technology for Climate Change Mitigation and Adaptation –*Dave Cown*
- Biofuel – A Green Energy Option for Mitigating Humanitarian Crisis of Climate Change –*Anoja Wickramasinghe*
- Status of Green Manufacturing Practices among Southeast Asian Wooden Furniture Manufacturers –*Jegatheswaran Ratnasingam*

12:30 – 14:00 *Lunch*

14:00 – 15:30 *Green Technologies* (Chair: *Jegatheswaran Ratnasingam*)

- Issues of Formaldehyde Emission From Wood Composite Products of Malaysia –*Koh MP*
- Tannin Resorcinol Formaldehyde as Potential Glue for Plybamboo Manufacture –*Adi Santoso*
- Liquefaction Technique of Woody Biomass Waste and Application for Bio-Based Wood Adhesives –*Shinichiro Tohmura*

15:30 – 16:00 *Coffee Break*

16:00 – 18:00 *Green Technologies* (Chair: *Koh MP*)

- Wood Waste Utilization for Wood Composite Industries in Malaysia –*Rahim Sudin*
- The Possibility of Utilizing Sawdust Wastes as A High Quality Activated Sawdust Charcoal –*Gustan Pari, A.*
- Energy-Efficient Manufacturing Practices among Wooden Furniture Manufacturers in Malaysia –*Jegatheswaran Ratnasingam*
- The Status of Wood Processing and Issues in PNG – Mathias Niangu

19:00 *Welcome Dinner*

Day 2	***15 December 2009***

08:30 – *Depart Hotel for Field Trip*

Day 3	***16 December 2009***

08:30 – 10:00 *Green Products* (Chair: *GS Rawat)*

- Sustainable Harvesting and Value Addition of MAPs In Community Forest in Dolakha, Nepal –Maneesha Rajbhandari
- Role of Neem Tree (*Azadirachta indica* A. Juss) To Solve Global Problem in Indonesia –*Zuraida*
- Improved Tapping of Philippine *Canarium* Trees For Manila Elemi: Helping Alleviate Climate Change –*A. B. Ella*

- Design and Development of Sawdust Burner for Kiln Seasoning of Timber –*D K L K Senadheera*

10:00 – 10:30 *Coffee Break*

10:30 – 12:30 *Green Products* (Chair: *A B Ella*)

- Jute: A Raw Material for the Production of Biomaterials – *M Sarwar Jahan*
- Adaptation to Climate Change and Non-Timber Forest Products: An Empirical Study in West Bengal, India –*Jyotish Prakash Basu*
- Bamboo as Green Material- Saves the Forest –*Anwar,U.M.K*
- Utilization of Bamboo Fibre-Filled Polypropylene Composites – Effect of Filler Loading and Coupling Agents – *Lee Sun-Young*
- Carbon Sequestration Potential and Uses of *Dendrocalamus srictus –Jyoti Bhandari*

12:30 – 14:00 *Lunch*

14:00 – 15:30 *Bioenergy and Biofuel* (Chair: *Sim HC*)

- Fuelwood Emission and Co2 Mitigation Strategy: A Case Study of Western Himalayas of India –*G S Rawat*
- Cultivation of Jatropha Seeds to Mitigate Climate Change Impacts in India: An Analysis –*Sahana Bose*
- Utilization of Alternative Timber Species by Preservative Treatment with Copper Chrome Boron –*K S G S Fernando*

15:30 – 16:00 *Coffee break*

16:00 – 17:30 *Panel Discussion* (Chair: *Dave Cown*)

17:30 Closing

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