

Carbon Capturing Potential of Wood Substitution in Domestic and Office Furniture in India

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Abstract

The changes in temperature have been attributed to increasing concentrations of atmospheric carbon dioxide and other green house gases in the atmosphere and major concerned at present. Greenhouse gases naturally act as a blanket “known as Greenhouse Effect” of the Earth and facilitate for maintaining about 33 degrees Celsius temperature. Over the past century, the Earth’s temperature has increased by about 0.50 degrees Celsius.

The carbon concentration in the atmosphere may be reduced by two approaches. Keeping the atmospheric CO₂ concentration below 450–600 ppmv poses an unprecedented challenge to humanity and can be attained by two main approaches: (1) to reduce emissions; (2) to capture CO₂ and store it, i.e., through sequestration. Carbon sequestration involves two steps: (1) CO₂ capture from the atmosphere (2) storage. The present study deals with the second approach storage.

The study concludes that in India the requirement of raw materials such as wood, metal and plastic for furniture annually was 11.6 Mm³, 4.46 Mm³, 1.78 Mm³ respectively. Based on the analogy as defined in the methodology, the replacement of 1 M³ metal or plastic by wood would save 2 tons of carbon dioxide emission. Therefore, this results of the saving of 624000 tonnes CO₂ emission against 5% of replacement of each metal and plastic as furniture raw material by wood. This study advocates, use of wood as raw material for furniture, which have a significant potential for mitigating the climate change impacts.

Key Words: Carbon, CO₂, Furniture, Green house gases, Wood.

I. INTRODUCTION

Over the past century, the Earth’s temperature has increased by about 0.50 degrees Celsius due to increase in concentration of the gases such as carbon dioxide, methane, nitrous oxide, and fluorocarbons [1]. The large-scale combustion of fossil fuels is a main cause of increasing the carbon dioxide (CO₂) concentration in the atmosphere, contributing to global climate change [2,3].

The carbon concentration in the atmosphere may be reduced by two approaches. Keeping the atmospheric CO₂ concentration below 450–600 ppmv poses an unprecedented challenge to humanity and can be attained by two main approaches to reduce emissions and to capture CO₂ and store it, i.e., through sequestration. Carbon sequestration involves two steps: CO₂ capture from the atmosphere and storage. First option revolves around the low emissions of carbon by reducing energy use, improved and innovative technologies of clean energy [4]. The low emission strategy will be the pathways to reduce the GHG and Non GHG’s emissions and thus, facilitate for the mitigation of climate change. Capturing of carbon from the atmosphere is possible from carbon sequestration by tree (natural) and mechanical sucking from atmosphere. These both approaches are much more expensive because of the low CO₂ concentration in

the atmosphere and associated complex process of technologies [5]. The sucking carbon from atmosphere is costly affair, therefore not much prevalent across the world and significant amount of research is continuing in this respect. The storage of carbon is possible by increasing the C sink stock in the industrial sector and household affairs. Choices about the low emission’s material use for different anthropogenic requirements can help to address the carbon dioxide (CO₂) emissions [6]. Stored carbon is significant only for wood and wood products as steel contain insignificant amount of carbon and plastic materials contain carbon, but much lower than the wood.

Wood has the unique ability to do both reducing emission by reducing carbon sinks and storing in it. Wood is primary content of the stems of woody plants, especially trees [7] and made of cellulose fibres and lignin and constitutes about 50% stock of carbon (C) on dry basis and sequester from atmosphere through the photosynthesis process. Harvested wood products (HWP) include wood and paper products [8] act as a carbon sink by retaining carbon for long time [9-11].

However, the potential benefits of utilising wood products to reduce carbon dioxide emissions is not well recognised in the decision-making of governments, public agencies and individual

consumers. Now, revised IPCC guidelines facilitated recognition of HWP by proving options to accounting of this in carbon pool [12]. Besides this, in general, over the past century the use of wood for building material has also decreased due to the introduction of alternative construction materials such as concrete, iron, cement and various composites. The use of wood derived packaging and furniture has also decreased significantly with the introduction of plastic and paper packaging materials.

II. METHODOLOGY

Wood substitution replaces other inputs of production in providing equivalent service or function. This is possible in two ways. These are i) wood instead of fossil fuels (fuel or direct substitution), and ii) wood instead of non-wood materials (material or indirect substitution) [13]. Thus, in the context of this study wood substitution means increasing the transformation of forest biomass into wood products to replace products emitting more GHGs per functional unit. The scope of the paper is use of wood for furniture in industrial and domestic sectors of India. This discussion contains all the furniture made by either fresh forest biomass or, recovered wood and fibres (i.e. wood at the end of its first life cycle). Analytically, use of fresh forest biomass, in replacing carbon intensive energy and material, has an impact on the forest structure and the carbon balance of the forest, both in the short and longer term. Use of recovered wood and fibres, in contrast, utilizes biomass which has been lifted out of the *in situ* biological cycle of growth and decay. But in the carbon perspective, the carbon contained in both ways is considered the stocks outside the forest domain.

Huge possibility of the amount of CO₂ reduction from the atmosphere is existed via the use of wood as raw material for furniture in place of metal and plastic. The substitution of wood in place of metal provides two pronged savings of carbon emission. Firstly, by saving of emissions against the construction related emissions during development of metal product, and second, by storing the carbon for long time in wood to be substituted in place of metal.

Carbon storage in wood

“Wood products are carbon stores, rather than carbon sinks, as they do not themselves capture CO₂ from the atmosphere. They act as a source for enhancing the carbon sinks by extending the period of CO₂ captured by the products of forests [14].

The present study provide an estimate of the total carbon benefit of wood based on the volume

used and how much carbon it stores, and the greenhouse gas emissions avoided by using wood instead of steel and plastics for furniture industries. The wood contains on average 50% of carbon by weight, calculating the volume of carbon contained in furniture was relatively straight forward, once the volume is known. The calculation of avoided emissions is complex, in general. However with the use of the study conducted by Frühwald (2003), the factor of 2 tons carbon dioxide savings can be assumed against the substitution of 1 m³ metal or plastic through wood. This includes 1.1 t carbon savings due to avoided emissions and 0.9 t carbon stored in wood due to use of 1 m³.

In order to ensure the precise result, the volume of different materials used for furniture makings is determined based on the proportions available in secondary sources described below. These proportions were used to define the quantitative volume of wood, plastics and metal mainly steel in furniture industries.

Wood use and demand for residential and official furniture in India

The furniture sector in India has a marginal contribution of 0.5% in the GDP. The Indian furniture market, "non organized" has major share of 85 per cent in cottage industries. The non organized sector of furniture industries concentrates in the wooden furniture segment mainly for home furniture, and the organized sector produces wooden, metal and plastic furniture mainly for office uses. About 65 per cent of the furniture produced in India is wood based, 25 per cent of metal, and the remaining 10 per cent of plastic. Most common wood furniture is made of Teak wood (60 %) and Rose wood (15-20 %) [15].

Wood in Furniture in India

The major sectors of domestic consumption of timber are housing and furniture manufacturing. The projected demand for 2001 and 2006 is reported in Table 1 as per the study by FSI [16]. The volume of wood projected by the study has been taken as the total consumption of wood during 2006 in the absence of any other reliable estimates. The estimates may not be correct, rather under estimated based on the scenarios perceived during the period for projections. The economic development between the expected growth and actual realisation in 2006 may not be similar and therefore may create bias estimates. Still, the projected volume of wood was considered for estimation of volume of other materials and wood used for furniture makings based on the defined proportions.

Table 1: Timber consumption (in Mm³) for year 2001 and 2006 (Projected)

Category	Region	2001	2006
Housing & allied domestic industry	Rural	31	34
	Urban	8	9
	Total	39	43
Furniture	Rural	6.3	7.0
	Urban	4.1	4.6
	Total	10.4	11.6

Source: FSI, 1996

Analysis for Carbon saved against substitution

While the carbon store effect of wood products helps keep CO₂ out of the atmosphere, an even greater carbon gain comes from the substitution effect of using wood in place of other, more fossil fuel- intensive, materials. Data differ according to material as well as to country (due to differences in energy sources), however all agree that concentrations of adorable CO₂ savings can be made by using wood instead of other materials. On average, one cubic metre of wood saves around 1.1 tonnes CO₂ emissions in comparison to the production of an equivalent amount of fossil fuel - intensive materials, such as steel, concrete or plastics. This amount, coupled with the 0.9 tonne of CO₂ stored in the wood, means that every cubic metre of wood substituting for fossil fuel - intensive materials saves a total of roughly 2 tonnes of CO₂ [17,18]. This statistics was used to estimate the potential of wood substitution against the materials such as metal and plastics for domestic and offices purposes.

III. RESULT AND DISCUSSION

Raw material for furniture

The total raw material in furniture industry has been estimated based on the proportion, defined in methodology as per previous studies. Based on the proportion and wood consumption, described in methodology i.e. 65% furniture is made from wood on the consumption of 11.6 Million m³ wood, and under the assumption that the projected consumption of wood during the period was as per report, the estimation of volume for the other two raw materials i.e. metal and plastics may be derived. This analysis is based on the assumptions that the ratio is prevailed currently with the same volume of wood consumption. Therefore, based on simple arithmetic calculation, the consumption of metals will be as follows:

Metal consumption with 25% share
 $= 11.6/65*25 = 4.46 \text{ Mm}^3$

Plastic consumption with 10% share
 $= 11.6/65*10 = 1.78 \text{ Mm}^3$

Based on the analysis, the estimated consumption of different metals in the furniture is reported in Table 2.

Table 2: Estimated consumption of different raw materials for furniture

Raw material	Proportion*	Consumption (Mm ³)
Wood	65	11.6
Metal	25	4.46
Plastic	10	1.78
Total		17.84

*-IBEF, 2008

Therefore, the total demand of raw material for furniture is 17.84 Mm³ with the assumption that volume of materials is similar to the wood for substitution purposes.

Therefore, the total savings against the total substitution of metals and plastics with wood under consideration with a fresh use will help to achieve the emission reduction in the tune of 12.48 million tonnes. However, this is neither practical nor achievable; therefore different scenarios have been developed with the assumption of substitution of different proportions of metal and plastic with wood in the following paragraphs.

Scenario for the HWP substitution against the metal and plastic

The modelling of the consequences of a future substitution of wood in place of metallic and plastic furniture in domestic and office use furniture, based on the framework that :

- Every cubic metre of wood substituting for energy intensive materials saves a total of roughly 2 tonnes of CO₂ with saving of emissions during development of products and locking in wood.

Scenario 1:

Substitution of 10% metal and plastic, each substituted with HWP

Total raw material for office and domestic uses as furniture is 17.84 Mm³ with the share of 11.6 Mm³ of wood; 4.46 Mm³ of metal, and 1.78 Mm³ of plastic. Therefore, the 10% substitution as per the scenario would have been saved the CO₂ emissions to the tune of 1.248 million tonnes as per the following calculations (Table 2). The 10% metal as raw material will be replaced by 0.446 Mm³ (10*4.46/100

Mm³) of wood, thus the CO₂ saving would have been 0.892 million tonnes (2 * 0.446). Similarly, the 10 % substitution of plastic with wood would have been facilitate the saving of carbon emission in the tune of 0.356 million tonnes.

Mm³) of wood, thus the CO₂ saving would have been 2.676 million tonnes. Similarly, the 30 % substitution of plastic with wood would have been facilitated the saving of carbon emission in the tune of 1.068 million tonnes (Table 3).

Scenario 2:

Substitution of 30% metal and plastic, each substituted with HWP

The 30% substitution as per the scenario would have been saved the CO₂ emissions to the tune of 3.744 million toones as per the following calculations (Table 3). The 30% metal as raw material will be replaced by 1.338 Mm³ (30*4.46/100

Scenario 3:

Substitution of 50% metal and plastic, each substituted with HWP

Based on similar calculations, the raw material substitution for metal and plastics could be 2.23 Mm³ and 0.89 Mm³, respectively. This would have been saved the total emissions in the tune of 6.24 million tonnes (Table 3).

Table 3: Emission saving due to wood substitution

Raw material	Substitution proportion	Substituted volume (Mm ³)	CO ₂ savings (in Million tonnes)
Metal	10	0.446	0.892
Plastic	10	0.178	0.356
Total		0.624	1.248
Metal	30	1.338	2.676
Plastic	30	0.534	1.068
Total		1.872	3.744
Metal	50	2.23	4.46
Plastic	50	0.89	1.78
Total		3.12	6.24

Based on above calculations for various scenarios for substitution of raw material by harvested wood products, the emission reduction due to the plastics, metal and total has been depicted in Figure 1.

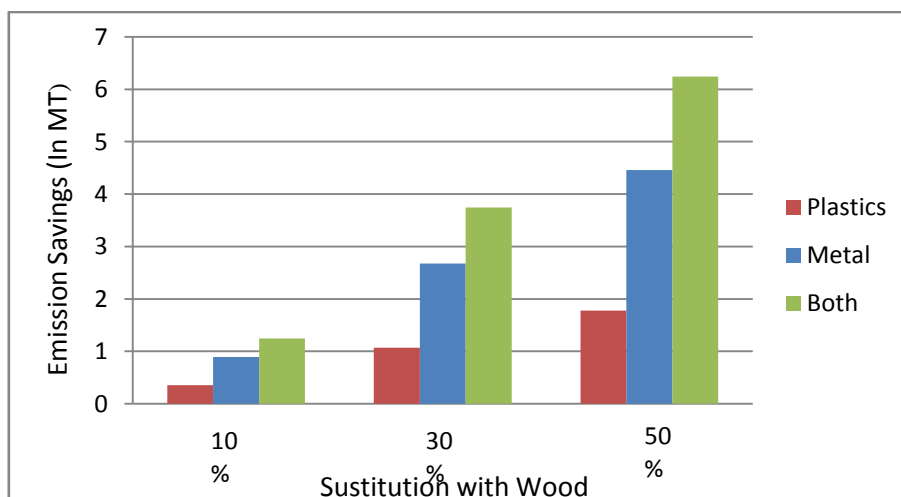


Figure 1: Possibility of emission savings against the substitution of HWP

To be more realistic, it was assumed to derive the emission reduction possibility against the practical approach of replacing metals and plastics at the proportion ranges from 1 to 20%. The emission

reduction strategy and volume has been reported in Table 4 based on straight calculation of emission reduction as per the approach defined in methodology.

Table 4: Emission savings due to wood substitution with varied proportions for furniture industry

Substitution Proportion	Reduction of CO ₂ against substitution of metal in tonnes	Reduction of CO ₂ against substitution of plastics in tonnes	Total reduction of CO ₂ against substitution of both metal and plastic tonnes
1	89200	35600	124800
5	446000	178000	624000
10	892000	356000	1248000
15	1338000	534000	1872000
20	1784000	712000	2496000

IV. CONCLUSION

The study concludes that in India the requirement of raw materials such as wood, metal and plastic for furniture annually was 11.6 Mm³, 4.46Mm³ and 1.78Mm³, respectively. Based on the analogy as defined in the methodology, the replacement of 1 M³ metal or plastic by wood would save 2 tons of CO₂ emissions. Therefore, this results of the saving of 624000 tonnes CO₂ emission against 5 % of replacement of each metal and plastic as furniture raw material by wood. These study advocates, use of wood as raw materials for furniture, which have a significant potential for mitigating the climate change impacts.

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REFERENCES

- [1] J. A. Patz, D. Engelberg, and J. Last, The effects of changing weather on public health. *Annu. Rev. Public Health*, 2000, 21, 271–307.
- [2] J. T. Houghton, L. G. M. Filho, B. A. Callander, N. Harris, A. Kattenberg, and K. Maskell, Climate Change 1995 The Science of Climate Change, Intergovernmental Panel on Climate Change, pp. 572, Cambridge University Press, Cambridge, GB, 1996.
- [3] L. Gustavsson, K. Pingoud and R. Sathre, Carbon dioxide balance of wood substitution: comparing concrete- and wood-framed buildings, 2004.
- [4] V. K. Yadav and R. Pandey, Carbon capturing potential of wood substitution in India (Lambert academic publishing, 2011).
- [5] N. Zeng, Carbon sequestration via wood burial. *Carbon Balance and Management*, 2008, 3(1). Doi: 10.1186/1750-0680-3-1.
- [6] R. S. J. Tol, Why worry about climate change? A research agenda. *Environmental Values*, 2008 17 (4), 437-470.
- [7] G. Babcock, Recycled substrate in specialty mushroom production - compost & raw materials, 2007, Retrieved from <http://www.entrepreneur.com/tradejournals/article/167779294.html>. accessed on 13 march, 2011.
- [8] IPCC, Good Practice Guidance for Land Use, land-Use Change and Forestry. Penman, J., Gytarsky, M., Hiraishi, T., Kruger, D., Pipatti, R., Buendia, L., Miwa, K., Ngara, T., Tanabe, K. and Wagner, F. (Eds), Intergovernmental Panel on Climate Change (IPCC), IPCC/IGES, Hayama, Japan, 2003.
- [9] R. K. Dixon, S. Brown, R.A. Houghton, A. M. Solomon, M.C. Trexler and J. Wisniewski, Carbon pools and flux of global forest ecosystems. *Science*, 1994, 263 (5144), 185–190.
- [10] K. Pingoud, A. L. Perälä and A. Pussinen, Carbon dynamics in wood products. *Mitigation and Adaptation Strategies for Global Change*, 2001, 6 (2), 91–111.
- [11] K. Pingoud, I. Savolainen and H. Seppälä, Greenhouse impact of the Finnish forest sector including forest products and waste management. *Ambio*, 1996, 5(5), 318–326.
- [12] IPCC, Guidelines for National Greenhouse Gas Inventories: Harvested Wood Products, 2006, Retrieved from www.ipcc-nggip.iges.or.jp/public/2006gl/index.htm, accessed on 14 March, 2011.
- [13] L. Gustavsson, K. Pingoud and S. Roger, Carbon dioxide balance of wood substitution: comparing concrete- and wood-framed buildings. *Mitigation and Adaptation Strategies for Global Change*, 2006, 11 (3), 667-691.
- [14] European confederation of woodworking industries, Tackle climate change- use wood, 2006, Retrieved from <http://www.cei-bois.org/files/b03500-p01-84-eng.pdf>, accessed on 15 Feb, 2011.
- [15] IBEF, Furniture, 2008, Retrieved from www.ibef.org/download/Furniture_010809.pdf. accessed on 21 Feb, 2011.
- [16] FSI. Fuelwood, Timber and Fodder from Forests of India, India, 1996.
- [17] A. Frühwald, University of Hamburg – ‘The Miracle of the Carbon Cycle’, 2002.
- [18] A. Frühwald, J. Welling & Scharai-Rad, Comparison of wood products and major substitutes with respect to environmental and energy balances, ECE/FAO seminar: Strategies for the sound use of wood, Poiana Brasov, Romania, 24-27 March, 2003.