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Review Article

Nonuse of Forest Residues is Impermissible Overlook for the Country with Limited Natural Resources

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Abstract

In human history forests always satisfied different needs of people like: food, energy, medicine plants, wood materials, fodder. From 20th century wood energy gradually was substituted by fossil fuel. But wood still remained irreplaceable resource for construction, furniture, paper industry. At the same time many new wood products have been developed from wood and agriculture residues, so called engineered wood, like: plywood, chipboards, fiberboards, MDF, etc. Bio-economy today uses biomass for manufacturing bio-based chemicals, plastics, pharmaceutical products as well as, residues for generating bio-energy. Nowadays, when the fossil fuel age declines due to its exhaustible character biomass regains a new importance. Biomass currently is the dominating renewable energy source for multiple use. Gradual substitution of fossil fuel by renewable energies instigates rapid growth of all renewable energy carriers like wind, solar, hydro, geo-thermal and bio-energy. It is the best strategy against climate change too.

Key words: forest, residue, waste, wood, bio-fuel, bio-refinery, chip

Introduction

Climate change is considered the most significant challenge of the world today. One of the means for mitigation of climate change consequences can be replacement of fossil fuels by renewable sources of energy and improvement of energy efficiency [1]. Until the end of the 20th century wood was considered as major energy source in the world, but then it was substituted by mineral oil and coal as having more energy potential and wood was mainly used in paper and furniture production, though in most developing countries of Africa and Asia it remains as major energy even today. In last decades wood energy came back in the focus of society and policy-makers as a renewable energy source to tackle issues of secure energy supply and climate change. In particular the European Union and its member states set policy target for renewable energy to increase on 20% by 2020 [2].

Among renewable sources of energy biomass play a major role in satisfying energy needs of the world. Biomass for energy originates from variety of sources classified into forestry, agriculture and waste streams. Some of the potential sources include: forests, wood biomass and residues, crops for bio-fuel, energy grass, short rotation forests and municipal solid waste. In 2012 the major part of bio-mass energy came from forests, almost 49 EJ out of total supply of 56.2 EJ. The World Bio-energy Association (WBA) estimates that by 2035 about 5% of the agricultural area can be used for growing dedicated energy crops for bio-fuels and solid bio-mass for energy [3].

By the conservative estimate potential of bio-mass from forestry, agriculture and waste sectors will total 150 EJ in the next 20 years. Approximately 43 % from agriculture (residues, by-products and energy crops), 52 % from forests (wood fuel, forest residues and by-products of forest industry) and 5 % from waste streams [4]. The substitution of fossil fuels by renewable once in future will require substantial growth of all renewable energy carriers like solar, wind, hydro, geothermal and bio-energy.

Forestry residues are divided in primary and secondary residues. Primary residues include residues accruing from cultivation, harvesting and logging activities, from trees within and outside of forests. The latter includes landscape management (including urban green spaces). Secondary residues accrue in the wood processing industry, such as sawdust, woodchips, black liquor. These by-products of the processing industry are already utilized in a variety spheres as fiberboards and panels [5-7].

Wood for energy comprises different categories such as: wood fuel, charcoal, woodchips, pellets, bark, saw-dust, recycled wood, black liquor and other residues of forest harvest and wood industry. Some of these materials go directly from the forests to the energy consumers like fire wood, tops, branches and small size wood. Other wood goes firstly to the industry (stem wood to saw mills, to the pulp industry) and residues in form of chips, saw dust, bark etc., that go to the energy sector. It must be underlined that in countries without bio-energy policy, a big share of these by-products is not used but dumped in landfills and rotten.

Results and analysis

2.1 Residues of forest loggings and industrial processing

Any kind of wood that is not considered for further use is residue or wood waste. Usually there are two types of residues: logging residues and industrial waste. Logging residues include: crowns, branches, damaged logs left in forest, cutting residues, stumps, stem off-cuts, trimmings. Industrial waste include log transportation residues that may be logs left or rejected at loading stations. Primary processing waste include: sawdust, trimmings, defective parts caused by wood processing, bark, core, slabs, and veneer waste. Secondary processing waste are: sawdust, shavings, mold wood, old construction roofs and stakes and so on [8-9].

The main sources of wood residues and waste are: forest biomass (generated mainly from commercial timber, log processing, cones, leaves, needles, branches, stumps and so on); residual by-products of wood processing (lumber, logs, firewood, veneer damaged cuttings, shavings, fencing materials: posts, poles, rails, bark, sawdust, chips, shavings) and urban wood waste(residues from urban management activities, lawn maintenance, municipal waste that include: everyday household and business garbage, buildings construction and demolition waste) (table 2.1.1)[10-11].

Building material types were analyzed in Germany to estimate the amount and quality of wood contained in the housing stock. The majority of wood was found in residential buildings as part of roof structures, walls and ceilings. The research made in Bavaria showed that 45% of the recovered wood from deconstruction can potentially be used as raw material for particle or fiberboard production. Much work remains in terms of efficient deconstruction of buildings to extract wood and other salvageable materials in good condition. Great amount of natural resources, energy and labor are embodied in building materials that often send to landfills after demolishing buildings [12].

Table 2.1.1 Forest residues from different sources

Source	Kind of residues
From loggings	Branches, needles, leaves, stumps, low quality and rotten wood, sawdust, chop offs
From sawing	Bark, sawdust, cracked wood, trimmings, dust, shavings
From plywood production	Bark, core, sawdust, chop offs, powder dust
From production of different kind of boards	Bark, trimmings of boards, sawdust, powder dust

Source: Zoya Tariq.2013. Utilization of Waste Wood. University of Arid Agriculture, Rawalpindi, Pakistan. 10pp. [11]

2.2. Residues for industry and agriculture

The spheres of using forest residues and other wood waste are: pulp and paper industry, different kind of boards, chemist industry, fodder for cattle and domestic animals, fuel for energy production, etc(table 2.2 1).

Expansion of pulp and paper industry from the end of the 20th century put great pressure on the traditional sources of the best coniferous wood species for pulpwood in many parts of the world. Result of this pressure was rapid expending use of wood residues in pulp production. It is considered that half of the fiber necessary for paper production is coming from wood and the other half from sawdust, straw, and even hemp. Coniferous species like spruce and fir-tree of course are the best source for paper production as the cellulose fibers in pulp of these species are longer and as a result the paper is becoming harder. Today, among the sources of paper production are used the residues of deciduous species like, poplars, elm-trees, etc. Besides, due to increasing demand on office paper and modern processing technologies, practically all species of trees are used for paper production in forestless areas such as: bamboo, flax, sugar-cane, etc.

Table 2.2. 1 Spheres of using forest residues

Types of residues	Pulp and paper industry	Boards	Chemical industry	Food	Fuel	Others
1.Chop residues, among them:						
Slabs, lathes	+	+	+	-	+	+
Cracked wood of sawing and lathes	+	+	+	+	+	+
2.Soft residues, among them:						
Sawdust	-	+	+	+	+	+
Shavings	+	+	+	+	+	+
Tree dust	-	+	-	-	+	-
3.Wood bark	-	+	+	+	+	+

Source: Zhuravliova L.N., Deviatlovskaya A. N. 2007.The main directions of using forest residues. Lesosibirski branch of Siberian State Technical University. Lesosibirsk, R.F. 7pp. [13]

In hydrolytic production the main source is sawdust (about 38-41%). For example, from 1 ton of birch tree sawdust, after chemical processing we can get 185 liters of ethyl alcohol, 44kg.of fodder albumen yeast, 5-6 kg. Furfural, 70 kg. Liquid carbonic acid, and other valuable products. In pyrolysis process from one cubic meter of birch-tree residues we can get 100 kg. Charcoal, 20 liter acetic acid, 5-6 liter wood-spirit and 10-15 kg. Pitch for making turpentine spirit, colophony rosin, etc. One of the most valuable products of wood-chemical production is charcoal which is widely used in different branches of economy [13].

Exhaustion of wood production base in most countries of the world increased demand on residues for pulp and paper industry. For example in Finland more than 85% of forest residues are used in pulp and paper industry [14-15]. Due to limited forest resources Norway use their forest residues in pulp and paper and boards making industries by ratio of 50/50. Increased demand on forest residues enlarged foreign trade of these resources among countries. Some countries are selling or buying residues and some of them are occupied with both businesses [16-18].

Another important option for wood waste is feedstock for so called engineered wood that is the material derived from smaller pieces of wood that are bonded with different glues, resins and other chemicals to make wood-like product. Engineered wood include chipboards, particleboards, laminated timber, medium-density fiber (MDF), etc. By the way, MDF is denser than plywood and can be used as building material like plywood and particleboard. Major uses of particleboard are furniture, core stock, floor underlayment, wall paneling, interior applications, etc.

Table 2.2.2. Chemical composition in trees of different species (%)

Chemical composition %					
Category	Volatile Substances	Ashes	Lignin	Cellulose	Hemicellulose
Soft wood species	0-5	0.5	25-35	40-45	25-28
Pine	0,7	0,5	34.5	40.4	24.9
Hard wood species	0-5	1	15-25	40-50	25-40
Poplar	1	2.1	25.6	41.3	32.9

Source: McKendry P. 2002. Production from biomass (part 1): Overview of Biomass. Bio-resource Technology 83. pp. 37-46. [19].

Today one of the major fields of using wood energy is pellet production from wood residues [20]. Beside wood residues for source of pellet production are used peat, bark, sawdust, chips and other residues and waste of loggings and agriculture, like maize waste, straw, waste of cereals, husks of sunflower, etc. Pellets are ecologically clean fuel with ash content of 3% and lesser. Pellets differ from wood by high dryness (moisture of pellets-8-12%, moisture of damp wood is 30-50% [13]. It guarantees their higher warming capacity comparing ordinary firewood of hard wood species. Hardwood tree species tend to contain more hemicelluloses and less lignin than soft-woods. Ratio of cellulose and lignin is the main factor that determinates the priority use of wood species for energetic purposes (table 2.1.3). In different countries pellets are of different size and quality. Production of pellets are growing every year in many countries of the world. Beside wood residues in pellet production are used small diameter trees getting from young forests thinning operation, biomass utilization of forest stand shrubs and low-value trees.

The simplest and cheapest use of forest residues is their use as fodder additives and fertilizers. Sawdust without any further processing can be used as fodder additives for cattle up to 25 % of total fodder composition. Bark contains more mineral substances (3-5.5 % of total volume) than sawdust useful for agricultural plants. Besides, bark has ability to infiltrate and adsorption of detrimental components for plants coming down with water. Using bark and sawdust as fertilizers is better after composting. Composting process increase nitrogen composition in fertilizer that increase soil structure and fertility. Fodder composts are the natural, organic fertilizers as bark contains much lignin and has big humus potential [13].

2.3 Some adverse effects of excessive extraction of residues

Forests provide a number of environmental services from which the major are: soil and water protection, carbon sequestration, biodiversity, which must be maintained during and after harvesting. Removal of residues after harvesting can increase the risk of detrimental effects on these services. Therefore, there is conflict between increased extraction of forest residues on one side and ecosystem services with long-term site sustainability from the other [21-22]. Removal of forest residues after harvesting might increase risk of detrimental effects on the environment services provided by forests such as: soil and water protection, carbon sequestration and biodiversity. In order to minimize the adverse effects following the forest residue extraction new research and guidelines are needed to be developed [23]

The existing practice of developed countries show that forest residue extraction is more suitable for clear-felling method, than for selecting loggings due to the fact that space for moving around in letters is limited. Some other impediments can be: long distance, steep terrain, small felling size and ecological restrictions. In most cases it is recommended that about 25% of logging residues must be left on site. The most important elements for tree growth are ammonium, potassium, calcium, magnesium, nitrate, sulfate and phosphorus. From extracted forest residues branches, twigs, leaves and needles have the largest part of nutrients within the tree. Hardwood species usually have higher nutrient concentrations than coniferous. Leaves as a rule have the highest mineral content from all tree parts. Therefore, decay of leaves is a very important process by which minerals are returned to soil [24].

Excessive extraction of forest residues can reduce soil organic matter (SOM), destabilize carbon-nitrogen balance, Increase erosion risks and reduce nutrient availability through removal of branches and tops. Therefore establishing sustainable guidelines for acceptable extraction rates is critically needed. The further uncertainties concerning achievable extraction rates for forest residues are created by uncertain future climate impacts like extreme weather and storm events affecting forest stands [25].

2. 4 Present level of using forest residues in Georgia

In early centuries Georgia's territory was covered with thick forests, but due to historical reasons in early and middle centuries (constant foreign invasions), as well as extensive overexploitation in the 20th century, resulted in deforestation and forest degradation of major part of forests. This detrimental process continued intensively after breakup of the Soviet Union until 2010 [26, 27]. According to informal information about 5-6 million cubic meter of valuable forests (mostly beech) was annually logged illegally and taken abroad for very cheap price. Currently the situation improved a little but still stay at high level, taking into account the present condition of forests.

Table 2.4.1 Total volume of logging by regions (cubic meter)

Region	2000	2005	2010	2015	2016	2017	2918
Georgia, total	442,140	810,615	876,749	712,336	628,035	630,462	578,031
Adjara AR	44,648	73,007	77,868	75,510	65,422	69,034	58,631
Guria	24,463	56,384	16,193	12,269	8,526	13,185	9,268
Imereti	45,270	103,718	97,440	80,775	57,443	53,277	45,483
Kakheti	61,893	119,479	181,706	140,086	121,773	132,o67	97,051

Mtskheta-Mtianeti	36,029	68,938	86,944	74,956	63,545	66,790	52,485
Racha-Lechkhumi and Kvemo Svaneti	52,706	52,713	37,148	60,919	59,145	49,523	50,114
Samegrelo-Zemo Svaneti	55,923	110,376	91,524	29,019	39,538	49,564	54,202
Samtskhe-Javakheti	72,483	123,253	94,374	89,170	79,784	81,956	102,682
Kvemo Kartli	20,757	44,100	89,704	52,496	44,222	42,799	34,343
Shida Kartli	23,227	52,369	103,848	76,661	71,284	58,267	58,257
Protected areas	-	-	-	20,475	17,353	14,001	15,515

Source: Ministry of Environment Protection and Agriculture of Georgia
LEPL Forestry Agency of Adjara
LEPL National Forestry Agency LEPL Agency of Protected Areas.

The major part of rural population in Georgia use firewood for warming and cooking meal. In the Soviet Period the greater part of firewood was imported from Russia, but presently this source is closed due to the political and economic reasons [27]. In last decades annually was logged about 700,000 cubic meter of wood by principle loggings (table 2.2.1). Average illegal loggings in the same period was about 45,000 cubic meter (table 2.2.2) [28]. So, altogether annually was logging about 745,000 cubic meter. In our forest practice logging residues never been estimated and used. They have always been neglected, left in forests and rotten. Only the residues of forest processing were used in the Soviet period. In 1980s about 40,000 cubic meter of chip-boards have been made that were used in doing school and office furniture [28]. Today, if we take only 30 % of residues and it is about 260,400cubic meter and leave 20%-about 112,000 cubic meter in forests, we can use 260,400 cubic meter for board, paper and fuel production. .

Practice of other countries show that the ratio of commercial wood taken from forest and the amount of residues left in forests not vary much and depends considerably on local conditions and species. Ratio of 50/50 is most often found in literature. E.G. for every cubic meter of log removed from the forest a cubic meter of waste remains in the forest. Other sources give a ratio of 60/40 e.g. 6 cubic meters of logs versus 4 cubic meters of waste remained in forest. The 40% consists of stem wood (above first branches), branch wood, natural defects, stem wood below first branches, felling damage, stump wood and other losses including sawdust, chop offs etc.[13] After sawing and further wood processing another 25-35 % of residues are left that consist: sawdust, trimmings, powder dust, shavings, chop offs etc.

Table 2.4.2 Illegal logging by regions (cubic meter)

Region	2005	2010	2013	2014	2015	2016	2017	2018
Georgia, total	61,042	32,802	6,039	45,915	44,612	28,586	35,022	32494
Adjara AR	2,676	2,040	1,671	1,895	1,880	1,044	1,514	1,250
Guria	1,436	333	225	474	729	647	331	194
Imereti	8,673	1,717	1,182	9,105	3,087	3,958	4,539	6,947
Kakheti	13,299	3,757	432	565	18,686	9,568	9,685	5,769
Mtskheta-Mtianeti	8,480	4,698	102	20,498	1,576	993	447	362
Racha-Lechkhumi and Kvemo Svaneti	1,672	613	268	802	1,993	320	2,032	1,717
Samegrelo-Zemo svaneti	3,052	916	236	2,291	1,766	2,119	3,928	1,562
Samtskhe-Javakheti	16,342	15,977	752	1,583	10,648	7,170	9,022	6,253
Kvemo Kartli	1,747	1,934	229	6,636	1,783	1,738	1,227	6,015
Shida Kartli	3,665	817	188	1,596	1,581	845	2,975	1,632
Protected areas	-	-	756	472	883	185	324	793

Source: Ministry of Environment Protection and Agriculture of Georgia

LEPL Forestry Agency of Adjara

LEPL Agency of Protected Areas

LEPL National Forestry Agency

In 1975 was worked out the General scheme of forestry development of Georgian SSR and provision of the country by forest resources on 1976-1990 [29]. After detailed research of forests of the country was concluded that 55% of forests were 0.5 density and lower. High density forests of 0.8-0.9 remained only 6.1 %. According to the regulations of selecting loggings in mountain forests of the country loggings are permitted on slopes up to 35^0 of steepness and at least of 0.7 density. High density forests are growing mostly on slopes of steepness above 35^0 and more [30, 31]. Unfortunately this regulation is violated as a rule and ecological problems and biodiversity are sacrificed to economic problems. At the same time adverse effects of extensive loggings result in: increasing soil erosion, soil degradation, water resources decrease, loss of biodiversity and other detrimental irreversible processes.

Conclusions

Climate change threatens global development led by excessive use of fossil fuels. The rapid replacement of fossil fuels by renewable energies is the essential strategy against climate change. Currently biomass is the dominative source for multiple use in different branches of economy. The global consumption of wood is likely to increase in future due to population growth and increasing demand for biomass. Utilization of biomass of forest, agricultural and urban wood waste along with residues from urban management activities, lawn maintenance and municipal waste that include: everyday household and business garbage, buildings construction and demolition waste is getting economically more and more popular. At the same time decrease of world forest area, deforestation and forest degradation threaten with shortage of forest raw timber and residues and what is most important loss of world's biodiversity and climate change. It is obvious that local governments are not able to control the constant acceleration of this process. So this process must be monitored by such non-governmental organization as UN, FAO and others. They must be given extra rights to control and if it's necessary to impose sanctions on those countries which are noticed in unsustainable forest management, overexploitation and forest degradation.

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