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WORLD EXPERIENCE FOR GEORGIA

ASSESSMENT OF WOOD AND AGRICULTURAL RESIDUE BIOMASS ENERGY POTENTIAL IN GEORGIA

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Biomass provides a significant contribution to the world's energy supply and thus plays an important role in the fight against climate change reducing an impact from greenhouse gas emissions. Bioenergy accounts for only 10% of the global energy consumption at present[1] but the potential of bioenergy will be increasing in near future. Increasing of the role of biomass in energy supply requires the use of all available biomass resources in a sustainable way, without causing directly or indirectly negative impacts. Sustainable production of bioenergy can also reduce energy poverty; contribute to rural development, to increased economic activity and technological advancement.

Biomass is playing a major role in Georgia's energy supply. The recent studies indicate[2] that fuel wood may be the biggest indigenous energy source and along with hydropower it is a strong factor for reducing country's energy dependence. The same studies indicate that unorganized and poorly controlled exploitation of this energy resource is leading to rapid degradation of Georgia's forests in accessible areas resulting in significant environmental and economic damage. It is expected that the accessibility of fuel wood will continue to strongly diminish and may lead to further forest degradation and energy shortage in nearest years. It is necessary to look for alternative local energy resources that can substitute the fuel wood and provide the heating for population. Residual biomass waste of forestry and agriculture is an important candidate for such energy use that is being effectively used in many countries.[3]Our study also indicates that proper disposal and improved management of agricultural and forestry waste is an absolutely necessary measure to avoid the damage to wood and agriculture ecosystems caused by current practices. Effective utilization of the available biomass waste potential is a way of preserving the country's energy security and it may also lead to deployment of new modern technologies and knowledge which is a development factor in its own right. [4]

The main purpose of this report is to assess the available resources of biomass residues from forestry and agricultural activities and to evaluate their energy potential. This includes the residues from annual and perennial crops, and residues of woody biomass. Energy resources are evaluated and compared with data on different crops by different regions of Georgia. However, for more accurate regional bioenergy planning a more detailed assessment of regional spatial distribution of crop residues is needed. One also has to take into account the alternative use of crop residues for forage or returning to the soil for preserving the soil quality.

This study is an attempt to make a preliminary estimation of biomass potential in Georgia and to offer the recommendations for future research. The report covers three main sources of potential biomass – wood biomass from forestry, woody biomass from perennial agricultural crops and biomass of annual crops.

[1]World Bioenergy Association - http://www.worldbioenergy.org/

[2] Renewable Energy potential of Georgia and Policies for its Utilization - WEG 2008 http://weg.ge/wp-content/uploads/2012/12/renewable_energy1.pdf

[3]Household Energy End-Use Survey, USAID Hydropower And Energy Planning Project (HPEP) June 20, 2014

[4] Recommendations for Effective Energy Supply Caucasus Environmental NGO network CENN – February, 2014

The preliminary assessment indicates that there is a great energy potential of biomass in Georgia that is practically wasted now, and even more, it creates a significant negative environmental impact on the forests and agricultural land. Such a condition requires a more comprehensive environmental assessment and programmatic approach in order to use the existing potential and reduce the environmental damage in a systemic and sustainable way.

The study is based on a desk research and interviews with knowledge field experts. Paper is divided into 3 parts, each part offers separate research conducted by different experts:

1. Assessment of Agricultural Residue Availability from Perennial Crops in Georgia – by Rusudan Mdivani
2. Annual Crop Residual Biomass by Regions of Georgia – by Giorgi Badrishvili
3. Wood waste and Alternative Woody Biomass Potential in Georgia – by Merab Machavariani

Data for this study were collected from several publications of the National Statistics Office of Georgian (GeoStat, 2012-2013), FAO (Food and Agricultural Organization of the United Nations) database (www.fao.org) (FAOSTAT), different articles from local and international resources and interviews with experts. The 2010-2013 official agricultural statistics data of yield and planting area at the county and regional levels for each type of crops are accessible from the National Statistics Office of Georgia, FAO-STAT and Ministry of Agriculture.

The quality of data and statistics reporting was the main limiting factor of the study. A more accurate research using the field visits and satellite imagery and GIS-based analysis could provide more accurate picture of the current national forests, orchards/plantations, crops and the biomass residues that can be available for energy use.

Acronyms

GJ – Giga Joule
Ha – hectare
KWh/kg – Kilowatt hour / kilogram
MJ – Mega Joule
PJ – Peta Joule
RCA – Residue to Cropping Area
RPR – Residue to Product Ratio
Thd – thousand
t –ton

Summary

The large part of Georgian population traditionally practices gardening, growing field crops etc. and uses wood for heating or cooking. Total area of the country's territory is 69.7 thousand sq. km. 40% of which is covered by forests. Nearly 2.6 million hectares is agricultural land, including 468 thousands hectares of arable land, 115 thousands hectares of land with perennial crops and 1940 thousand ha of permanent meadows and pastures. Agricultural sector of Georgia plays an important role in the state's economy, contributing 7% of GDP while wood sector contributes 0.5% of GDP [5]

Perennial Crops

According to the research the following findings and estimations have been made:
Total of 304Kt of agricultural residue, with 5.6 PJ of energy resource is generetad in Georgia from perinnial crops production. The energy potential of perennial crops' residue is 1.565 TWh/year. Main resource for perennial crop residues are:

- Vineyard's pruning residue
- Friut orchards' pruning residue
- Hazelnut shells and cuttings
- Bay leef cuttings

Total Residue 108kt, with 2,0PJ total energy resource is annually yelded in Georgia from established vineyards. According to the research, there are 37 419 hectares of vineyards in Georgia and energy value of residue per unit of area is 54.2 GJ/Ha. *Vineyards have the biggest potential in agricultural residue of Imereti, Kakheti, Racha Lechkhumi and Kvemo Svaneti and Kvemo Kartli regions*.

Vineyards have the biggest part in agricultural residue of Georgia, but they are not used as an alternative heating source, most of the residues are left in the field or burnt. According to the information, provided by farmers, the transportation and storage costs are much higher than value of alternative heating resource. There is a clear tendency to increase the area under grape plant; accordingly, through establishment of modern intensive vineyards the amount of produced biomass will increase.

Fruit orchards are also an important source of biomass. Total Residue 81kt, with 1.5 PJ total energy resource is available from fruit orchards. At present, the total land area occupied by orchards has decreased by more than 60% to about 40,000 hectares out of which up to 12,000 hectares are focusing on apple production and 10,000 hectares are focusing on citrus.

As the result of data analysis, the apple orchard pruning leaves the highest residue (21 715 t) and bio-energy resource (406074 GJ) in Shida Kartli region; pear orchards' pruning has highest residue (1 140 t) and bio-energy resource (21318 GJ) - again in Shida Kartli region; peach orchards' pruning highest residue (5 289, 6 t) and bio-energy resource (99444GJ) - in Kakheti region.

The third biggest provider of agricultural residue in Georgia is hazelnut: Currently, hazelnuts represent 24% of Georgian agricultural exports. Estimated number of hectares in cultivation is up to 15 000 hectares under hazelnut plantations. Hazelnut orchards, as well as processing capacities, have grown intensely in Georgia reaching 40,000 tons of raw hazelnuts harvested annually or about 5% of world supply. 67629t biomass/ 1 264 671 GJ energy are available every year from hazelnut production in Georgia.

[5] http://geostat.ge/?action=page&p_id=118&lang=geo

Main hazelnut producer regions are Samegrelo-Zemo Svaneti (area – 10114 ha, Total Residue – 28 319 kg, Total energy production - 529 569 GJ), Guria (area – 3339 ha, Total residue – 9 349 t, Total energy production -174 830GJ) and Imereti (area – 1305 ha, Total Residue – 3 654 t, Total energy production – 68 330 GJ)

Hazelnut generates the residues in the form of fronds and shells. About 10 fronds are shed per tree per year, yielding about 1.4 kg. Dry woody biomass per frond or, assuming a density of 200 trees per ha, about 2,800 kg. Per ha

Hazelnut shells are used as an alternative heating source in cities and suburban areas of Samegrelo and Guria Regions. Average harvest of hazelnut is up to 40 000 ton/year. Yielding up to 24 800 ton/year of shell residues. About 1.55 ton dry shell residue becomes available per hectare per year. Average Heating Value for hazelnut is 1.6 PJ.

Table 1.Main hazelnut producer regions:

Region	Total Residue from Shell kg	Total energy production GJ
Samegrelo-Zemo Svaneti	15 676 700	293 154
Guria	5 175 450	96 781
Imereti	2 022 750	37 825

Bay leaf is also an important source of residue. Due to favorable climatic and soil conditions this plant is mainly spread in the western regions -Adjara, Samegrelo, Guria and Imereti - of the county. 9000 t residue of bay leaf is available totally in Georgia, which can be used as 0.2 PJ energy resources. Most part of biomass from bay leaf 7 500 ton is available in Samegrelo-Zemo Svaneti region.

Annual Crops

Residue for Annual Crops, including straw of wheat and barley, corn Stover and cobs, kidney bean, oat and sunflower were also assessed during the research. Totally the land under ***wheat*** varied between 45 000 – 59 000 ha within 2006 – 20013. There are several registered varieties cultivated in Georgia, but basically the wheat is produced in Kakheti, Kvemo Kartli and Shida Kartli regions. As experts and farmers reported the wheat is providing 200 (+/- 20) pressed bales (16 kg +/- 2kg each) per ha equal to 3 t/ha straws on average after the harvest. The total amount of wheat residue made up 135 t equivalent to 2.28 PJ/year. Wheat straw is mainly left in the field after harvesting or might be burnt in the field which is not a recommended activity since the land surface and soil fertility get degraded. In a best case the remained straws are pressed in bales and taken for animal feeding or for commercial purposes.

The minimum sown area under ***barley*** was in 2012 about 14 000 ha. Like the wheat, its straw can generate 16.92 MJ/kg heating value and based on statistics of 2013 the total energy potential would be 1.5 PJ/year. As an alternative use of barley straws except of biomass, the straw is one of basic component of fodder and used for animal feeding intensively during the winter time.

The highest coverage area by ***corn*** was reported in 2013 which made up 150 400 ha. Both, corn Stover and corn cob have high energy value and each of them generate 15.98 PJ/year (corn stover) and 2.35 PJ/year (corn cobs), totally 18.3 PJ/year in 2013.

Kidney been- According to dynamics of sown area since 2006 the lowest point was registered in 2009 about 5 500 ha, but in 2013 the interest on kidney been demand increased and reached to 8 400 ha. The kidney been is mostly cultivated in Shida Kartli around 3 800 ha. In terms of residue energy value the energy potential is less compared to other crops- about 0.03 PJ/year.

Sunflower in the eastern part of Georgia has the potential to yield 4.5 – 6 t/ha crop residue and 1.5–2 t/ha seed yield. Sunflower was sown in 4200 ha in Kakheti (Dedoplistskaro, Signagi municipalities) region in 2014, and to convert residue balance into energy value theoretically it could generate 1.2 PJ/year.

As for **oat,** it was sawn in 2 300 ha and to convert into heating value ratio it made up 0.12 PJ/yea.

Wood waste and Alternative Woody Biomass Potential in Georgia

Forests are one of the most valuable natural resources in Georgia. They occupy about 40% of the territory of the country. The estimated total wood stock volume amounts to 451, 7 million m^3; the average annual increment of the wood is approximately 3.7-4, 5 million $m^{3.}$

Wood waste Biomass produced through forestry is mainly of two origins:

a) Biomass residue from timber harvesting and logging in the form of tree tops, branches and foliage, Stump (excluding roots) and sawdust.

b) The biomass resulting of primary timber processing at sawmills, in the form of slabs, edgings and off-cuts, Sawdust and fines, bark and various losses. Currently in Georgia there are 67 active forest use license holders operating about 180 thousand hectares of forest. The total wood volume to be harvested over the licensed period is 2 832 834 m^3

Table 2.

Source of origin	Accumulated m^3	Energy value accumulated **PJ** (HV=14.7MJ/kg)	Annual potential, m^3	Energy value Annual potential **PJ**(HV=9.8MJ/kg)
License holders	500 000	4.4	25 000	0.2
Local Population	511 000	5.2	150 000	1.1
Illegal cut	1 875 000	19.3	625 000	4.8
Sub Total	**2 886 000**	**28.8**	**800 000**	**6.1**
Sawmills	227 000	2.4	36 000	0.3
Early & Mid-term Tending and Thinning	-		250 000	1.8
Measures to support natural regeneration[6]	-		75 000	0.5
Sub Total	**227 000**	**2.4**	**361 000**	**2.6**
Total	**3 113 000**	**31.2**	**1 161 000**	**8.7**

* According to expert consultations, the condition availability and dryness of accumulated sawmill residues needs additional study. For energy value estimate we take half of potential residue to by air dry and half wet

Sawmills- According to the official information there are 688 wood processing sawmills in Georgia. According to FAO calculation, the amount of wood waste in the sawmills is 34% of processed round wood volume. There are no official data on the amount of biomass accumulated during the last years at sawmill territories. The study - "Potential of woody biomass in energy sector and their efficient use" in 2010 estimates this amount accumulated in previous years at around 228 000 m^3.

There are potential new sources of woody biomass that shall be utilized, such as (i) thinning operations, and (ii) support of natural regeneration that have accumulated considerable amount of woody biomass. In Soviet period and sometime after independence production of about 300 000 m^3 of timber through thinning operations was planned each year, though radical decrease of state funding after independence completely eliminated this activity from usual forestry practices in Georgia.

Over at least 20 years no thinning operations were conducted in Georgian forests, thus we can assume that potential annual cut will be about 500 thousand m^3 which corresponds to estimated current ecological condition of forests and the necessity of corrective actions of timber of which maximum 50%

[6] It is assumed that 5000 hectares are operated annually.

might be commercially utilizable wood, rest amount (250 000 m^3) might be considered as potential wood waste biomass.

In Georgia forests, a significant problem for natural regeneration is the high distribution of *Rhododendron* and *Laurocerasus* bushes mainly in broadleaved forest stands, which comprise more than 80% of forest cover, with more favorable climate conditions for their growing. By rough estimation about 10-15 m^3 of *rhododendro*n and *Laurocerasus* wood biomass is accumulated per hectare. Therefore, cleaning of only one thousand hectare of forest may produce 15 thousand m^3 very high energy value of alternative woody biomass 75 000 m^3.

There are considerable amounts of chestnut wood left in chestnut forest stands where private companies are operating. The main objective of their activity is to improve ecological conditions in these forests highly affected by chestnut blight disease and, thus they are obliged to undertake sanitary cut and remove all diseased trees. In practice companies are focused on cutting the best trees and leave diseased ones in the forest[7]. This has resulted in high number of standing dead trees. According to the rough estimation this may comprise some of 300 000- 400 000 m^3 of wood biomass.

For more business oriented purposes - a detailed study of actual available wood waste and alternative woody biomass potential is recommended as a future step. The primary objectives of such study are: (i) select the potential pilot regions for development of wood waste and/or alternative woody biomass use; (ii) undertake a detailed estimation in the selected regions of the volume of wood waste and alternative woody biomass, available for alternative energy production on a long-term sustainable basis; and (iii) prepare a plan for the business cycle, accounting explicitly for a range of environmental, operational, and economic assumptions.

Table 3.Below summarizes the total potential of available biomass waste energy by type of biomass.

Table 3.Summary of Waste Biomass Annual Energy Potential in Georgia

	Wood Residues	**Annual potential m3**	**Location Regions**	**Energy value PJ**
	License holders	25 000	Samegrelo Zemo Svaneti, Kakheti, Imereti	0.2
	Local population	150 000	Samegrelo Zemo Svaneti, Kakheti, Imereti	1.1
	Illegal cut	625 000	Samegrelo Zemo Svaneti, Kakheti, Imereti	4.8
	Sawmills	36 000	Imereti, Samtskhe-Javakheti, Samegrelo Zemo Svaneti	0.3
	Early & Mid-term	250 000	Samegrelo Zemo Svaneti,	1.8

[7] This is confirmed several times by relevant state authorities through their inspection reports.

	Tending and Thinning		Kakheti, Imereti	
	Measures to support natural regeneration[8]	75 000	Samegrelo Zemo Svaneti, Kakheti, Imereti	0.5
	Total for Woody residual biomass	**1 161 000**		**8.7**
	Perennial crop residues	**Amount – ton**	**Location Regions**	**Energy value PJ**
1	Vine pruning	108 000	Kakheti, Imereti, Racha-Lechkhumi, Kvemo Svaneti	2
2	Fruit orchard residue	81 000	Sida Kartli, Kakheti	1.5
3	Hazelnut	67 629	Samegrelo Zemo Svaneti, Guria, Imereti	1.6
4	Bay leaf	9 000	Samegrelo Zemo Svaneti, Adjara, Guria	0.2
	Total Perennial	**290 429**		**5.3**
	Annual Crop Residues	**Amount - Ton**	**Location Regions**	**Energy value - PJ**
1	Wheat	134 000	Kakheti	2.28
2	Barley	42 000	Imereti, Kakheti	1.5
3	Corn straw	1037 000	Samegrelo Zemo Svaneti,Imereti	18.3
4	Kidney bean	8 400	Shida Kartli	0.03
5	Sunflower	19 000	Kakheti	1.2
6	Oat	2 300	Kakheti	0.12
	Total Annual Crops	1 242 700		**23.4**
	Total Plant Biomass Residues			**37.4**

According to the research, one can conclude that the highest potential energy from biomass waste is coming from the forestry. It amounts to 40 PJ or more than 11 Terawatt hours (TWh) which exceeds current annual electric energy consumption of Georgia. But this 40PJ energy comes from different sources, 31.3 PJ is already accumulated wood energy value and 8.7 PJ is annual potential. It has also to be mentioned, that Wood biomass, and sawdust in particular, is more concentrated and commercially interesting than other types of agricultural biomass.

[8] It is assumed that 5000 hectares are operated annually.

Corn straw seems to be the second largest potential energy sources with almost 18 PJ of annual potential. However this conclusion needs to be treated with more care and needs to be confirmed for the actual sown areas, per area yield of the residue and its current alternative use. The highest potential unused residue in perennial crops may be from vineyard pruning (2 PJ/a) this potential needs to be studied in more detail for current practice in the regions and might be also complemented by grape pressings from the wineries.

The biomass energy potential can satisfy the energy needs of an important part of Georgian population who now uses wood for heating and cooking. Generally, one household consumes 7 m^3 wood equivalent to about 61GJ of heat and there are 1,2 mln households in Georgia. The table below gives a number of households who can potentially be satisfied with energy produced from biomass residue:

Biomass residue	**Energy value (PJ)**	**Number of households (thousand)**	**Households that use wood %**
Wood biomass (accumulated)	31.2	508	92
wood biomass annual potential	8.7	141	26
Annual crops energy potential	23.4	381	69
Perennial crops energy potential	5.3	86	16

It is also noteworthy, that annually, 70 PJ gas is consumed in Georgia, and annual potential of biomass residue is 37.4 PJ equivalent to about half of total annual gas import.

In order to have a more realistic, detailed and comprehensive view on the biomass resources in Georgia further studies should be carried out to:

- ✓ Conduct the field visits to selected agricultural regions and forest areas;
- ✓ Confirm the actual territory of agricultural areas and waste biomass availability including:
- ✓ Study the current practice of pruning and residue yield;
- ✓ Verify the actual Residue to Product Ratio(RPR) by annual crops;
- ✓ Verify the actual residue yield from the field unit area;
- ✓ Differentiate most common crop varieties, since these may have individual yield of biomass residues e.g. the corn varieties of Western Georgia quite differs from Eastern Georgia varieties;
- ✓ Identify the current practice of alternative use of residues and current waste management practices for agricultural crops;
- ✓ Compile the data-base of crop distribution by crop type and sown/planted area by regions, with as much detail as possible;

- ✓ Examine the actual forest areas, their conditions and damaged areas with the high concentration of waste biomass;
- ✓ Conduct a field estimate of woody biomass available from each stage of forestry activities;
- ✓ Compile a data base of forestry residues;
- ✓ Consider developing of GIS system based on satellite information as reference system for data collection and analysis.

A combination of field visits, further on-site interviews and research, with modern methods of analysis like satellite imaging and compilation of GIS system data base are recommended for further studies.

Introduction

Biomass energy occupies a significant status in the world's energy consumption and in the fight against climate change. Sustainable bioenergy production can reduce energy poverty, contribute to rural development and avoid the negative environmental impacts such as decreasing greenhouse gas emissions [1]. Although bioenergy accounts for only 10% of global energy consumption at present, the potential of bioenergy will be very great in the near future.

Biomass is organic matter of contemporary biological origin. It includes all forms of organic matter such as
Agricultural crops, trees, all types of plant residues, wood, animal wastes, municipal wastes, sewage sludge, and other

A report from World Bioenergy Association (WBA) in 2010 stated that the reasonable and sustainable utilization of global biomass energy could meet global energy demand [2]. The U.S. Biomass Roadmap by the U.S. Department of Energy (USDOE) sets forth a goal that, by the year 2030, biomass shall supply energy approximately equivalent to 30% of current petroleum consumption [3]. Within Europe, the European Commission (EC) has set mandatory targets for an overall share of 20% renewable energy and a 10% share of renewable energy in transport in the EU's consumption in 2020 [4]. For Romania, the target set by the Renewable Energy Directive on the promotion of the use of energy from renewable sources for 2020 is a 24.0% share of energy in gross final consumption [5]. National estimates of the fraction of Australia's petrol usage that could be replaced by biofuels range from 10% to 14%?? [6].

Conversion of forest and agricultural residues to biomass feedstock for electricity generation and district heating is becoming a common form of bioenergy [4]. Rising energy price and emerging new technologies have renewed people's interest in conversing crop residues to energy products [7,8]. Cro residues such as the straws of cereal and corn, which can be converted into liquid or gaseous biofuels by thermo-chemical or biological techniques, are potential resources for the development of bioenergy [9]. Hence, crop residue is a viable option for energy production, especially for rural areas in developing countries. The accurate estimation of the amount of crop residues used for bioenergy is very important for the sustainable supply of biomass. Increasing attention has been paid to quantification of bioenergy potentials of crop residues. Joh et al. provided an overview of the current status of bioenergy development globally, focusing on biomass energy and the potential contribution of agricultural biotechnologies in developing countries [10]. Gary et al. assessed the availability of straw biomass energy used as feedstock in the Northwest Pacific in U.S.A. [11]. Nicolae et al. assessed the utilization potentials of straws for bioenergy purpose in the European Union [8]. Idania

Crop residues and dedicated bioenergy crops together constitute 3 – 9 EJ of bioenergy potential. This is about 4 – 13 % of the estimated total energy consumption in EU-27 for 2020.

et al. discussed the potential of bioenergy resources used in agricultural activities in Mexico, while presenting the spatial distribution of different crops [7].

There is a growing recognition that the interrelations between agriculture, food, bioenergy, and climate change have to be better understood in order to derive more realistic estimates of future bioenergy potentials [12]. The increasing role of biomass in future energy supply requires the use of all available resources in a sustainable way, without causing directly or indirectly negative impacts [5]. Some recent researches indicated that excessive straw reaping might have adverse impact on soil, environment and crop yield. Thu reasonable reaping (removal) ratio is needed for sustainability purpose. For example, Susan et al. [13] discussed the effect of straw reaping on soil quality, pointing out that sustainable straw reaping rates vary depending on factors such as management, yield and soil types. The Conservation Technology Information Center (CTIC) of USA provides assessments of conservation tillage practices and pointed out that the non-conservation tillage (intensive/conventional and reduced tillage) leaves less than 30% crop residue cover (CRC), while conservation tillage leaves more than 30% CRC [14]. A study sponsored by the National Renewable Energy Laboratory (NREL) and the US Department of Energy (DOE) showed that the use of corn stover as a feedstock for ethanol production in Iowa, USA, could be done without adversely impacting soil health, while providing significant energy and greenhouse gas benefits [15,16].

GEORGIA IS AGRICULTURAL COUNTRY WITH HUGE RESOURCES OF RESIDUE FROM AGRICULTURAL PRODUCTION.

Agricultural sector of Georgia plays a major role in the state's economy, contributing 9.3% of GDP (1.2.bln. GEL annually). Specific natural and economic conditions greatly affect Georgian agriculture. In terms of modern borders, total area of the country territory is 69.7 thousand sq. km. with nearly 2.6 million hectares of agricultural land, including 468 thousands hectares of arable land, 115 thousands hectares of land with perennial crops and 1940 thousand ha of permanent meadows and pastures (FAO 2011). The average use of land per person is 0.16 hectares of plough-land and 0.62 hectares of grazing land. Georgia is a country of high agricultural potential, but currently is not capable to use its potential completely.

Agriculture is based on a dual system of family holdings and commercial operators. More than 90 percent of the production is concentrated within highly fragmented small-scale family holdings. On average, the size of a family holding is 1.22 hectares, fragmented into two or three land parcels of 0.45 hectares on average. Around 82 percent of family holdings produce mainly for self-consumption, while the remaining 18 percent produce cash crops. About 25 percent of agricultural land is private and 30 percent is leased. About 1.3 million people are employed in this sector, which is 55% of the total employment of the country. This paper is focused on the assessment of availability of agricultural residue in Georgia as an energy resource, based on data from multiple sources (GeoStat, FaoStat, MOA, farmers, articles, etc.). Here are defined the available resources of main Perennial crops' residue by regions of Georgia. Energy production resources are evaluated and compared with data of different crops and different regions. However, a detailed assessment of spatial distribution of crop residues for different regions is needed for regional bioenergy planning. Moreover, not all crop are available for

biomass use because some of them should be returned to the soil as residue to prevent erosion and enhance soil quality. The previous methods remarkably overstated the crop residue yield since the part of cropland returning and reaping lose was not considered, and this part of residue should be left in the field to meet all the environmental and farming requirements. Crop residue burning is not an isolated practice. The most common justification that farmers give for burning are to get a seedbed that is easy to work and will not impede the growth of a new crop and to rid the fields of phytomass that can harbor pests and diseases waiting to reduce the next harvest. Although these claims have some validity, none can justify blanket burning of residues. Mechanical difficulties in tilling residue-laden fields can be managed either by using residues as evenly as possible or, preferably, by choosing an appropriate reduced-tillage operation.

Methodology for Perennial Crops

Data for this study were collected from several publications of the National Statistics Office of Georgian (GeoStat, 2012-2013), FAO (Food and Agricultural Organization of the United Nations) database (www.fao.org) (FAOSTAT), different articles from local and international resources.

The yields of agricultural residue were calculated based on the crop yield and the corresponding crop-to-residue ratios. Availability of agricultural residue were thereby obtained based on the crop yield, environmental consideration and soil requirements. Fresh weight for crop-to-residues ratios were mainly derived from the source of GeoStat and dry matter calculated by using average moisture values in NRC (National Research Council. 1971). Coefficient, established estimated from CEESTAT (Research Centre of Agriculture, Environment and Territory) and SESIRCA (Centre for Agriculture Research), compared with local data.

Two different methods can be used to calculate the amount of residues generated. The first one, often used for woody residues from perennial crops, is based on the cropped area. This method assumes that tree crops grow with a more or less standard planting density, which in practice may not be true. The type of management (traditional or advanced) as well as the crop variety (local variety, improved and/or clonal variety) can result in large differences in the amount of crop as well as residue obtained from a particular cropping area.

To calculate pruning residue (t/ha) for perennial crops we identify three different sources and take average amount from them. Two internet resources selected by big difference between their data (University of Perugia – Biomass Research Centre and Local information: producers (companies, farmers) and scientists). Third source was Local information: producers (companies, farmers) and scientists. In case of data absence on special trees, such is bay leaf, we compare it with the same type plants (Almond trees and Olive trees) [18, 19]. Same approach we had in definition of Heating value MJ/kg.

Source	Vineyard residue t/ha	Apple trees residue t/ha	Pear trees residue t/ha	Peach trees residue t/ha	Hazel trees residue t/ha	Almond trees and Olive trees, bay leaf residue t/ha
University of Perugia – Biomass Research Centre	2.9	2.4	2.0	2.9	2.8	1.7
University of Thessaly, Greece	5.1	4.9	4.9	4.6		4.5
Local information: producers (companies, farmers) and scientists	2-3	2-3	1.5-2.5	2.5-3	2-3	15[9]
Average agreed	2.9	2.4	2.0	2.9	2.8	15

The second method, often used for annual crops, is to use a residue to product ratio (RPR).With this method the amount of residues is calculated from the crop production using an average RPR value. This method enables the calculation of the amount of residues in multi-cropping systems as more than one crop may be grown on a certain area within a one-year period.

However, this method has the drawback that different crop varieties may have different RPR values (possibly even from year to year) which is caused by variations in weather, crop type grown, water availability, soil fertility, farming practices etc. Besides, in many cases the moisture content of residues is not given when reporting RPR values. Since moisture content can vary widely between fresh and air-dry biomass (differences of up to a factor of 3 in the case of bagasse), estimating the amount of residues using an RPR may result in inaccurate estimates [17].

Accurate research (i.e. using satellite imagery and GIS-based analysis) has not yet been carried out. As such, an accurate picture of the current national orchards/plantations cover or changes and trends in the general health of orchards is not available.The net agro-residue availability for bioenergy purpose would be estimated considering the requirements on soil conservation and transportation costs**.**

[9] The difference in pruning residues is due to different technologies of bay leaf production in Georgia and in Western countries

Vineyards' Pruning Residue

There are 37419 hectares of vineyards in Georgia, grown primarily in three regions and consisting of (primarily) ten different varieties of grapes. There was 10.4% growth in vineyard area from 2004 to 2008. There has been more increase since then.It should be noted that before approximately three times more hectares of vineyards were grown. This difference in production area points to the production growth potential in case the demand for Georgian wines starts to increase.

The amount of agricultural residues of vine pruning can be determined multiplying cultivation surface with a coefficient, which describes residues productivity (t/ha). Table I shows the average values of vine pruning residues in Georgia by regions and districts.

Table I. Area under vineyards and average values of vine pruning residues in Georgia by regions and districts

Location, Region/District	Area of vineyards, ha	Residue (t/ha)	Heating Value, MJ/kg	Total energy production, GJ/t
Georgia, total	37419	2.9	18,7	2 029232
Ajara AR	42	2.9	18,7	2278
Keda district	29	2.9	18,7	1573
Shuakhevi district	10	2.9	18,7	542
Khelvachauri district	3	2.9	18,7	163
Guria	268	2.9	18,7	14534
Lanchkhuti district	32	2.9	18,7	1 735
Ozurgeti district	45	2.9	18,7	2 440
Chokhatauri district	191	2.9	18,7	10 358
Imereti	8584	2.9	18,7	465510
Tkibuli district	179	2.9	18,7	9 707
Tskaltubo district	179	2.9	18,7	9 707
Chiatura district	599	2.9	18,7	32 484
Bagdati district	1 367	2.9	18,7	74 132
Vani district	1 098	2.9	18,7	59 545
Zestafoni district	2 229	2.9	18,7	120 879
Terjola district	1 363	2.9	18,7	73 915
Samtredia district	130	2.9	18,7	7 050
Sachkhere district	843	2.9	18,7	45716
Kharagauli district	514	2.9	18,7	27 874
Khoni district	84	2.9	18,7	4 555
Kakheti	22 227	2.9	18,7	1 205 370
Akhmeta district	1043	2.9	18,7	56 562
Gurjaani district	5 991	2.9	18,7	324 892
Dedoplistskaro district	1 339	2.9	18,7	72 614
Telavi district	3 854	2.9	18,7	209 002
Lagodekhi district	1 108	2.9	18,7	60 086
Sagarejo district	2 643	2.9	18,7	143 329
Signagi district	2 589	2.9	18,7	140 401
Kvareli district	3 660	2.9	18,7	198 481
Mtskheta-Mtianeti	792	2.9	18,7	42 950
Akhalgori district	17	2.9	18,7	921
Dusheti district	112	2.9	18,7	6 073

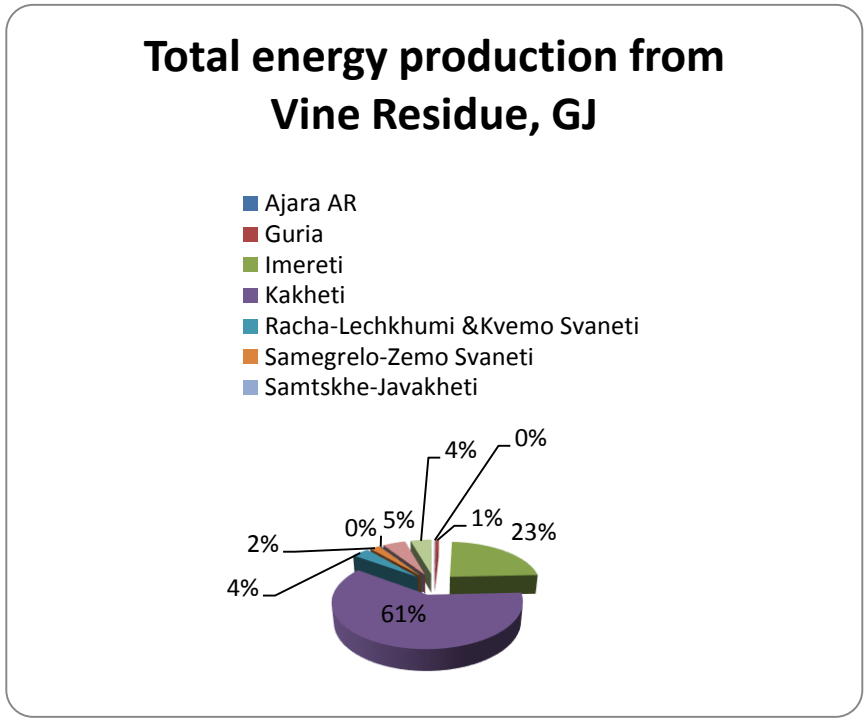
Mtskheta district	663	2.9	18,7	35 954
Racha-Lechkhumi&Kvemosvaneti	1348	2.9	18,7	73102
Ambrolauri district	628	2.9	18,7	34 056
Lentekhi district	18	2.9	18,7	976
Oni district	86	2.9	18,7	4 663
Tsageri district	616	2.9	18,7	33 405
Samegrelo-Zemo Svaneti	775	2.9	18,7	42028
Abasha district	4	2.9	18,7	216
Zugdidi district	213	2.9	18,7	11 550
Martvili district	227	2.9	18,7	12 310
Senaki district	60	2.9	18,7	3 253
Chkhorotsku district	136	2.9	18,7	7 375
Tsalenjikha district	100	2.9	18,7	5 423
Khobi district	34	2.9	18,7	1 843
Samtskhe-Javakheti	6	2.9	18,7	325
Akhaltsikhe district	5	2.9	18,7	271
Kvemo Kartli	1757	2.9	18,7	95282
Bolnisi district	674	2.9	18,7	36 551
Gardabani district	268	2.9	18,7	14 533
Tetritskaro district	159	2.9	18,7	8 622
Marneuli district	656	2.9	18,7	35 574
Shida Kartli	1622	2.9	18,7	87961
Gori district	267	2.9	18,7	14 479
Kaspi district	584	2.9	18,7	31 670
Kareli district	267	2.9	18,7	14 479
Khashuri district	503	2.9	18,7	27 277

Table II and diagram II show the average values of vine pruning residues in Georgia by regions.

Table II. Total energy availablefrom Vine Residue (GJ) in Georgia

Location, Region/District	Area of vineyards	Residue (kg/ha)	Heating ValueMJ/kg	Energy Production MJ/ha	Total Energy Production GJ
Georgia, total	37419	2900	18,7	54230	2 029232,37
Ajara AR	42	2900	18,7	54230	2277,66
Guria	268	2900	18,7	54230	14533,64
Imereti	8584	2900	18,7	54230	465510,32
Kakheti	22227	2900	18,7	54230	1 205370,21
Racha-Lechkhumi &Kvemo Svaneti	1348	2900	18,7	54230	73102,04
Samegrelo-Zemo Svaneti	775	2900	18,7	54230	42028,25
Samtskhe-Javakheti	6	2900	18,7	54230	325,38
Kvemo Kartli	1757	2900	18,7	54230	95282,11
Shida Kartli	1622	2900	18,7	54230	87961,06

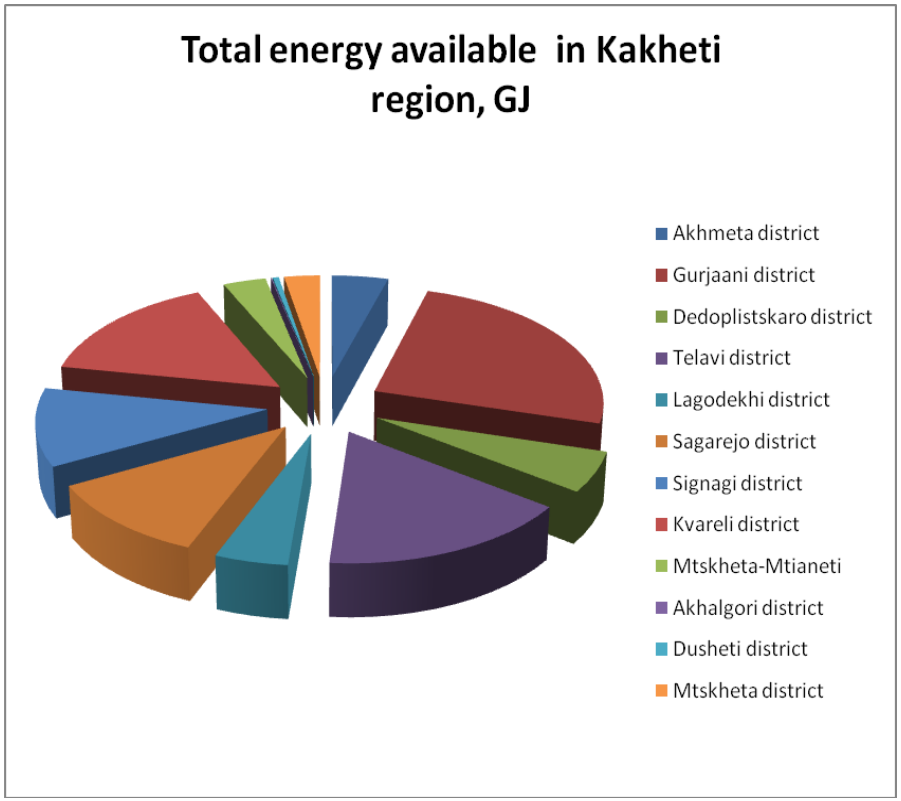
Diagram II. Resource for energy available from Vine Residue (GJ) in Georgia



According to given data, the main vine producer region is Kakheti with total energy production 1,2 PJ and main district – Gurjaani, with total energy production 0.324 PJ. The average values of vine pruning residues in Kakheti region by districts are given in Table III and Diagram II.

Table III. Total energy production from Vine Residue (GJ) in Kakheti RegionDiagram II.Resource for energy production from Vine Residue (GJ) in Kakheti Region

Kakheti Region, Districts	Area of vineyards, h	Residue (kg/ha)	Heating Value, MJ/kg	Total energy available in Kakheti region, GJ
Akhmeta	1 043	2900	18,7	56 561
Gurjaani	5 991	2900	18,7	324 891
Dedoplistskaro	1 339	2900	18,7	7 261
Telavi	3 854	2900	18,7	209 002
Lagodekhi	1 108	2900	18,7	60 086
Sagarejo	2 643	2900	18,7	143 329
Signagi	2 589	2900	18,7	140 401
Kvareli	3 660	2900	18,7	198 481
Mtskheta-Mtianeti	792	2900	18,7	42 950
Akhalgori	17	2900	18,7	921
Dusheti	112	2900	18,7	6 073
Mtskheta	663	2900	18,7	35 954



Residual biomass potential from perennial agriculture crops in Georgia consists of pruning of vine and fruit orchards, that are generally cut up and then land-filled, or burned near the field, with additional costs for farmers and serious problems about parasites development or uncontrolled fires. Based on information collected from Information-consulting center of Telavi, MOA, institute of horticulture, viticulture and oenology and TELAVI WINE CELLAR, the farmers use cuttings from vineyards as a heating resource, whereas big companies prefer to burn vine residue near the field. As shown in Table IV, owners of 99% vineyards in Kakheti are family farms. The big vineyard owners *break on the small pieces* a vine pruning residue and leave it in vineyards. This biomass is used as bio-fertilizer in vineyards for next year.

Table IV. Total number of holdings and its structure by holding type

	Number of Holdings				Structure of Holdings, %			
Districts	All Holdings	Family Holdings	Agriculture Enterprises	Others	All Holdings	Family Holdings	Agriculture Enterprises	Others
Kakheti	118 559	118 443	81	35	100	99,9	0,1	0
Akhmeta district	11 083	11 081	1	1	100	100	0	0
Gurjaani district	22 706	22 691	9	6	100	99,9	0	0
Dedoplistskaro district	10 198	10 172	25	1	100	99,7	0,2	0,1
Telavi district	20 283	20 239	32	12	100	99,8	0,2	0
Lagodekhi district	14 471	14 467	2	2	100	100	0	0
Sagarejo district	16 920	16 916	3	1	100	100	0	0
Signagi district	12 156	12 150	1	5	100	100	0	0,1
Kvareli district	10 742	10 727	8	7	100	99,9	0,1	0,1

Location, Region/District	Area of fruit orchards, ha	Number of trees in orchards	Number of trees in one ha orchard	Average Residue (kg/ha)	Average Heating Value, MJ/kg	Energy Production, GJ/ha	Total energy available, GJ
Georgia, total	36988	14 354 470	388,08	2200	**18**	39600	1 464724
Abkhazia AR (reported part)	37	4568	123,46	2200	18	39600	1465
Keda district	38	17367	457,03	2200	18	39,600	1504
Kobuleti district	279	217256	778,70	2200	18	39600	11048
Shuakhevi district	40	22252	556,30	2200	18	39600	1584
Khelvachauri district	37	24962	674,65	2200	18	39600	1465
Khulo district	5	2729	545,80	2200	18	39600	198
Guria	4017	1 98318	493,81	2200	18	39600	159073
Lanchkhuti district	1350	606830	449,50	2200	18	39600	53460
Ozurgeti district	2149	1 10617	514,74	2200	18	39600	85100
Chokhatauri district	517	270617	523,44	2200	18	39600	20473
Imereti	2038	961093	471,59	2200	18	39600	80704
Tkibuli district	24	5938	247,42	2200	18	39600	950
Tskaltubo district	379	97358	256,88	2200	18	39600	15008
Chiatura district	37	13222	357,35	2200	18	39600	1465
Bagdati district	27	9642	357,11	2200	18	39600	1069
Vani district	761	444211	583,72	2200	18	39600	30135
Zestafoni district	160	97235	607,72	2200	18	39600	6336
Terjola district	15	6383	425,53	2200	18	39600	594
Samtredia district	399	204346	512,15	2200	18	39600	15800
Sachkhere district	21	5655	269,29	2200	18	39600	831
Kharagauli district	6	1907	317,83	2200	18	39600	237

Khoni district	209	75196	359,79	2200	18	39600	8276
Kakheti	2860	957370	334,74	2200	18	39600	113256
Akhmeta district	90	25987	288,74	2200	18	39600	3564
Gurjaani district	1620	622938	384,53	2200	18	39600	64152
Dedoplistskaro district	1	483	483,00	2200	18	39600	39
Telavi district	313	104583	334,13	2200	18	39600	12394
Lagodekhi district	173	51530	297,86	2200	18	39600	6850
Sagarejo district	115	31959	277,90	2200	18	39600	4554
Signagi district	42	6414	152,71	2200	18	39600	1663
Kvareli district	507	113476	223,82	2200	18	39600	20077
Mtskheta-Mtianeti	1041	335497	322,28	2200	18	39600	41223
Akhalgori district	58	25472	439,17	2200	18	39600	2296
Dusheti district	244	89286	365,93	2200	18	39600	9662
Tianeti district	127	42337	333,36	2200	18	39600	5029
Mtskheta district	612	178390	291,49	2200	18	39600	24235
Racha-Lechkhumi&KvemoSvaneti	211	64208	304,30	2200	18	39600	8355
Ambrolauri district	64	17567	274,48	2200	18	39600	2534
Lentekhi district	3	1646	548,67	2200	18	39600	118
Oni district	34	9447	277,85	2200	18	39600	1346
Tsageri district	110	35548	323,16	2200	18	39600	4356
Samegrelo-Zemo Svaneti	11689	6 33972	542,32	2200	18	39600	462884
Abasha district	228	88788	389,42	2200	18	39600	9028
Zugdidi district	7205	3 50516	486,51	2200	18	39600	285318
Martvili district	463	319759	690,62	2200	18	39600	18334
Mestia district	19	4662	245,37	2200	18	39600	752
Senaki district	627	390618	623,00	2200	18	39600	24829
Chkhorotsku district	1256	887094	706,29	2200	18	39600	49737

Tsalenjikha district	1130	810374	717,15	2200	18	39600	44748
Khobi district	761	332561	437,01	2200	18	39600	30135
Samtskhe-Javakheti	1521	353311	232,29	2200	18	39600	60231
Adigeni district	413	74243	179,77	2200	18	39600	16354
Aspindza district	466	121248	260,19	2200	18	39600	18453
Akhalkalaki district	36	12790	355,28	2200	18	39600	1425
Akhaltsikhe district	603	144087	238,95	2200	18	39600	23878
Borjomi district	4	943	235,75	2200	18	39600	158
Kvemo Kartli	1281	429808	335,53	2200	18	39600	50727
Bolnisi district	112	26212	234,04	2200	18	39600	4435
Gardabani district	309	128263	415,09	2200	18	39600	12236
Dmanisi district	95	80050	842,63	2200	18	39600	3762
Tetritskaro district	9	2454	272,67	2200	18	39600	356
Marneuli district	751	192427	256,23	2200	18	39600	29739
Tsalka district	4	402	100,50	2200	18	39600	158
Shida Kartli	11894	2 64159	222,07	2200	18	39600	471002
Gori district	9044	1 92057	212,39	2200	18	39600	358142
Kaspi district	1024	316217	308,81	2200	18	39600	40550
Kareli district	1627	373649	229,66	2200	18	39600	64429
Khashuri district	199	30536	153,45	2200	18	39600	7880

Fruit orchards' Pruning Residue

Georgian fruit production has long been a tradition due to the country's moderate climate and multitude of micro-climates. Fruit production in Georgia became more commercialized in the late 1960s with a focus on production for export to other parts of the Soviet Union. At present, the total land area occupied by orchards decreased by more than 60% to about 40,000 hectares out of which up to 12,000 hectares are focusing on apple production and 10,000 hectares are focusing on citrus (Table V). The main fruit producer regions are Shida Kartli (11 894 ha) and Samegrelo Zemo Svaneti (11 689 ha) (Table VI. Diagram III).

Table VI. Average values of fruit orchards' pruning residues in Georgia by regions.

Location, Region	Area of fruit orchards, ha*	Number of trees in orchards*	Number of trees in one ha orchard	Average Residue** (kg/ha)	Average Heating Value, MJ/kg	Energy Production, MJ/ha	Total energy available GJ
Georgia, total	36988	14 354470	388,08	2200	18	39600	1464724
Abkhazia AR (reported part)	37	4568	123,46	2200	18	39600	1465
Guria	4017	1 983618	493,81	2200	18	39600	159073
Imereti	2038	961093	471,59	2200	18	39600	80704
Kakheti	2860	957370	334,74	2200	18	39600	113256
Mtskheta-Mtianeti	1041	335497	322,28	2200	18	39600	41223
Samegrelo-Zemo Svaneti	11689	6 339172	542,32	2200	18	39600	462884
Kvemo Kartli	1281	429808	335,53	2200	18	39600	50727
Shida Kartli	11894	2 641259	222,07	2200	18	39600	471002

Diagram III. Resource for energy available from Fruit Pruning Residue (GJ) in Georgia

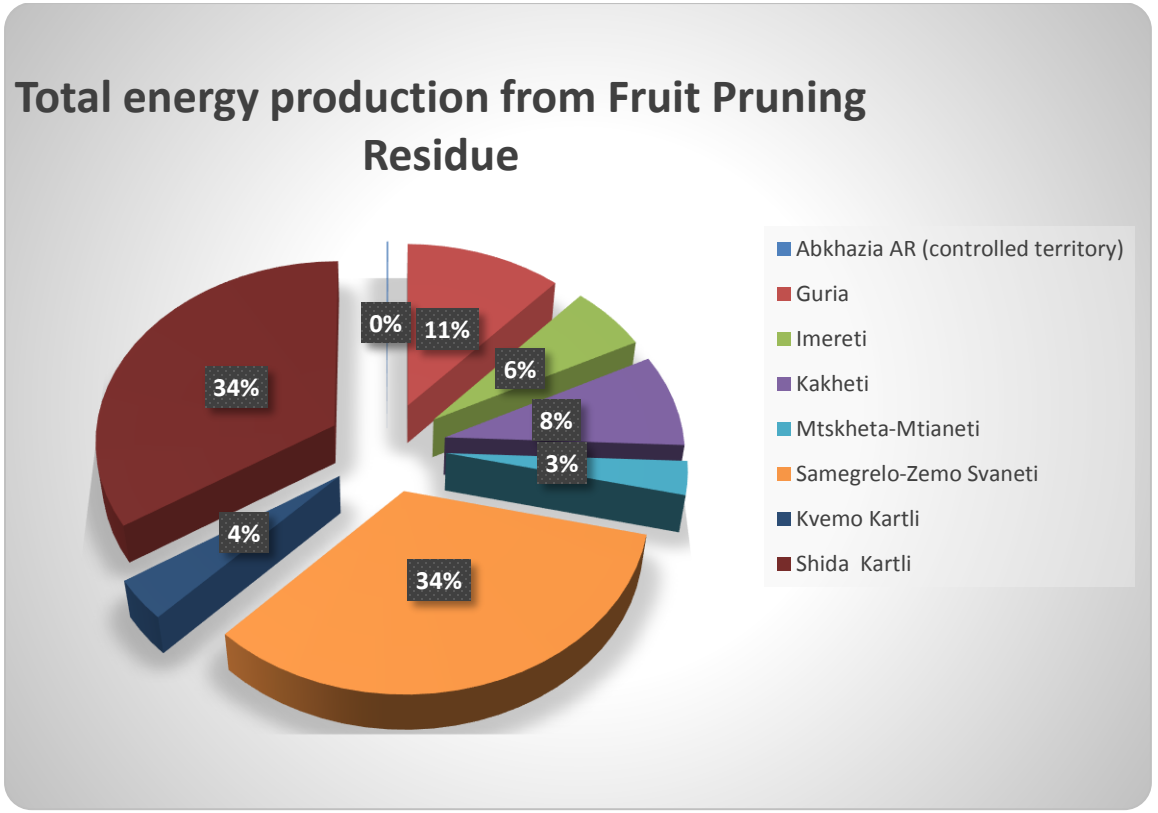
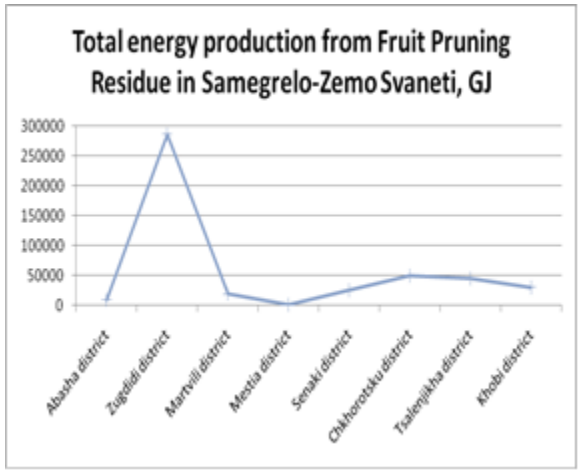


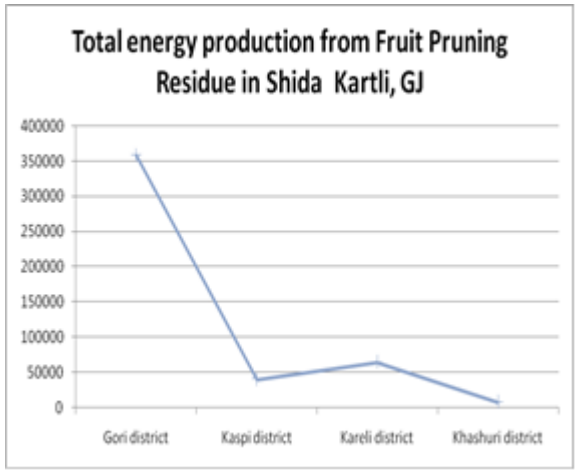
Table VII. Average values of fruit orchards' pruning residues of main fruit producer regions of Georgia.

Location, Region/District	Area of fruit orchards, ha*	Number of trees in orchards*	Number of trees in one ha orchard	Average Residue ** (kg/ha)	Average Heating Value, MJ/kg	Energy Production, MJ/ha	Total energy available, GJ
Samegrelo-Zemo Svaneti	11689	6 339172	542,32	2200	18	39600	462884
Abasha district	228	88788	389	2200	18	39600	9028
Zugdidi district	7205	3 505316	486	2200	18	39600	285318
Martvili district	463	319759	691	2200	18	39600	18335
Mestia district	19	4662	245	2200	18	39600	752
Senaki district	627	390618	623	2200	18	39600	24829
Chkhorotsku district	1256	887094	706	2200	18	39600	49737
Tsalenjikha district	1130	810374	717	2200	18	39600	44748
Khobi district	761	332561	437	2200	18	39600	30135
Shida Kartli	11894	2 641259	223	2200	18	39600	471002
Gori district	9044	1 920857	212	2200	18	39600	358142
Kaspi district	1024	316217	309	2200	18	39600	40550
Kareli district	1627	373649	237	2200	18	39600	64429
Khashuri district	199	30536	153	2200	18	39600	7880

From data analysis it is clear, that fruit orchard pruning residue energy resources are mostly concentrated in Zugdidi district (7 205 ha, 285318,000 GJ), Samegrelo and Zemo Svaneti Region and Gori district in Shida Kartli Region (9 044 ha, 358142,400 GJ) (Table VII, Diagram IV, V).

Diagram IV, V. Energy potential from Fruit Pruning Residue (GJ) in Samegrelo&Zemo Svaneti and Shida Kartli Regions.





Orchard structures (GeoStat) have been analyzed to identify most agro-residue energy value distribution by fruit in Georgia (Table VIII). As shown in the table VIII, the part of hazelnut orchards in Georgia is 49 percent; 22.2 percent of total orchards in Georgia are planted with apple trees. Accordingly, this two fruits can be defined as the main sources of agro-residue energy from fruit orchards pruning in Georgia.

Table VIII. Orchard structure by fruit, %

A - Apple; B - Pear; C - Quince; D - Plums; E - Cherry (including sour); F - Apricots; G - Peach; H - Sour plums; I - Cornel; J - Walnut; K - Hazelnut; L - Persimmon; M - Fig; N - Pomegranate; O - Kiwi; P - Feijoa; R – Mulberry

Location/fruit	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	R
Georgia, total	22.2	3.4	0.4	3.5	1.6	0.8	7.4	2.1	0.3	4.4	49.0	2.2	0.7	0.1	0.2	0.4	1.3
Abkhazia AR (reported part)	13	3,3	0	4,4	_	0,1	0,2	2,2	_	75,2	1,3	_	_	_	_	_	_
Gulripshi district	13	3,3	0	4,4	_	0,1	0,2	2,2	_	75,2	1,3	_	_	_	_	_	_
Adjara AR	9,4	4,7	0	1,9	0,8	0	0,4	2,1	0	9,7	67,6	1,9	0,5	0	0,3	0,3	0,2
Keda district	35	12	1	2,5	3,1	_	0,5	9,8	0	12,7	17,5	4	1	_	0	_	0,5

Kobuleti district	0,2	0,5	0	0	0	0	0,1	0,2	0	3,8	93,4	0,9	0	0	0,4	0,3	0
Shuakhevi district	46	20	2	11	2,1	0,1	0,1	4,3	_	13,4	1,2	0,1	0,3	_	0	0	0,1
Khelvachauri district	3,6	6,6	0	2,3	1,4	0,2	1,8	4,7	1	35,5	31	7,6	2,6	0,3	0,4	0,3	0,8
Khulo district	38	14	2	9,7	10	0,4	0,4	5,8	0	16,3	3	0,3	0,3	_	0	_	0,6
Guria	2,3	3,1	0	0,3	0,6	0	0,7	1,9	0	3,5	83,7	1,7	0,5	0	0,3	0,9	0,1
Lanchkhuti district	3,2	5,1	0	0,7	1,2	0,1	1,2	3,1	0	4,5	74,6	2,9	0,9	0,1	0,2	1,8	0,1
Ozurgeti district	1,5	1,9	0	0,1	0,2	0	0,3	1	0	3,3	89,2	0,9	0,2	0	0,4	0,6	0,2
Chokhatauri district	3,4	3,3	0	0,3	0,8	0	0,9	2,7	0	2	82,9	2,2	0,9	0	0,1	0,1	0
Imereti	5,7	3,5	0	1,2	1,8	0,2	1,6	6,9	0	6,2	60,3	5,1	0,8	0,5	0	0	5,8
Tkibuli district	39	13	1	1,7	1,5	0,2	1,4	15	0	8,1	15,7	2,2	1,3	0	0	_	0,3
Tskaltubo district	7,9	4,5	1	1,2	2,3	0,3	5,9	5	0	7,7	46,7	14,5	2,2	0,4	0	0,1	0,6
Chiatura district	23	9,4	3	7,8	4,5	0,2	3,1	8,5	0	25,5	7,7	0,5	1,7	0	_	_	5,1
Bagdati district	13	18	2	8,2	4,2	0,7	2,5	9,3	0	4,7	20,7	1,8	3,2	2,3	0	0,1	8,9
Vani district	5	3,4	0	0,7	1,4	0	1	4,3	0	4	74,5	4	0,4	0,8	0	0	0,3
Zestafoni district	3,7	1,8	1	1,5	2,8	0,2	0,7	27	0	16,2	26	7,2	1,4	0,3	0	0,1	10,7
Terjola district	10	5,7	2	3,4	2,9	7	2,7	3,6	_	25,8	21,4	4,2	1,6	0,5	_	0	9,1
Samtredia district	3,2	2,8	0	0,6	1,9	0,1	1	2,8	0	1,3	82	3,2	0,4	0,1	0	0,1	0,5
Sachkhere district	44	9,2	2	6,8	4,8	0,1	1,6	4	0	18,5	4,1	2	0,8	0,1	0	_	2,4
Kharagauli district	15	5,1	1	4,1	2,7	0,2	0,5	14	0	27,3	19,3	4,8	4,9	0,6	_	_	0,4
Khoni district	2	1,4	0	0,4	0,7	0	0,8	1,6	0	3	41,8	2	0,4	0,1	0	0,1	45,7

Kakheti	6.0	1.4	0.3	2.7	0.8	1.7	66.5	2.3	0.2	4.0	8.8	4.7	0.4	0.1	_	_	0.3
Akhmeta district	25	5,1	1	29	1,1	1,1	19	7,6	0	4,7	4	0,6	0,3	0,3	_	_	2,1
Gurjaani district	1,8	0,1	0	0,3	0,2	1,9	92	0,4	0	1,3	0,8	0,8	0,1	0	_	_	0,1
Dedoplistskaro district	17	9,9	5	12	6,1	12	2,6	6,3	1	20,3	3,7	1	2,1	0,5	_	_	0,6
Telavi district	12	2,5	0	1,9	0,8	1	69	0,7	0	3,6	5,7	1,3	0,4	0,1	_	_	0,6
Lagodekhi district	9,1	2,8	1	5,2	2	0,8	5,9	17	1	7,5	16,9	29,7	0,9	0,3	_	_	0,3
Sagarejo district	22	10	2	10	4,6	4,8	23	2,3	1	14,1	1,1	2	1,7	0,9	_	_	0,5
Signagi district	42	1,5	1	4,8	1,7	2,2	23	1,2	0	7,2	0,5	13	0,5	0,2	_	_	0,5
Kvareli district	5,4	1,3	0	3,3	1	0,5	10	2,9	1	10,8	48,6	13,6	1	0,2	_	_	0,4
Mtskheta-Mtianeti	19	9,1	2	20	7,2	4,2	11	5,4	1	13,5	1,2	2,5	2,2	0,6	_	_	1,1
Akhalgori district	24	13	2	22	8	1,9	3,2	3	1	19,7	0,9	0,6	0,3	0	_	_	0,7
Dusheti district	21	11	2	28	4,3	1,3	8,6	8,6	0	13,6	0,6	0,6	0,6	0,1	_	_	0,5
Tianeti district	28	7,3	3	40	1,8	0,1	0	2,9	0	15,1	1,1	_	_	_	_	_	0
Mtskheta district	15	8	3	11	10	7,2	15	4,8	2	12	1,5	4,4	4	1,2	_	_	1,8
Kazbegi district	100	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_
Racha-Lechkhumi &Kvemo Svaneti	36	7,7	1	13	3	0,2	3	2,2	0	29,2	2,8	0,7	0,6	0,1	_	_	0,4
Ambrolauri district	46	6,6	1	9,9	2,4	0,1	2	1,7	0	24,3	4,1	0,4	0,4	0	_	_	1,1
Lentekhi district	56	5	2	15	6,5	0,9	1,9	1,3	1	10	1	_	0,1	_	_	_	0,7
Oni district	27	11	1	4	2,3	0,2	1,2	1,7	0	47,6	3,4	0,2	0,1	0	_	_	0,2
Tsageri district	33	7,3	2	17	3,4	0,3	4,2	2,6	0	26,4	2,1	1	0,9	0,1	_	_	0,1

Samegrelo-Zemo Svaneti	2.3	1.9	0.1	0.2	0.4	0.3	0.7	1.8	0.1	2.9	84.6	2.1	0.9	0.0	0.3	0.9	0.5
Abasha district	4,3	3,8	0	0,6	0,7	0,1	0,7	5,8	0	3,6	57,4	9,6	1,4	0,2	0	0,5	11,1
Zugdidi district	2,4	2,1	0	0,2	0,5	0,5	0,8	1,3	0	2,8	84,4	1,4	1,2	0	0,5	1,3	0,4
Martvili district	1,8	1,8	0	0,1	0,2	0,2	0,8	5,4	0	1,8	78,7	8,7	0,2	0	0	0,1	0,1
Mestia district	47	22	0	6,7	5,2	0,1	0,2	7,9	0	10,1	0,2	_	_	_	_	_	_
Senaki district	6,2	4,5	0	0,7	0,9	0,1	1,8	2,5	0	3,4	71,1	5,6	1,6	0,1	0,1	0,8	0,2
Chkhorotsku district	1,2	0,9	0	0	0,2	0	0,3	0,5	0	2,3	92,8	1,1	0,2	0	0,2	0,1	0,1
Tsalenjikha district	0,3	0,3	0	0	0	0,1	0,1	0,2	0	3,5	94,3	0,7	0,2	0	0,1	0	0,1
Khobi district	2,8	2,7	0	0,2	0,6	0,2	0,6	8,1	0	3,4	75	2,7	1,4	0,1	0,5	1,1	0,2
Samtskhe-Javakheti	39	5,6	1	28	7,3	0,6	0,4	0,9	1	15,1	0,2	_	_	_	_	_	1,6
Adigeni district	65	6,9	1	14	5,2	0,4	0,3	0,5	0	7	0,1	_	_	_	_	_	0
Aspindza district	20	4,8	2	37	9	1	0,8	0,8	2	19,2	0,2	_	_	_	_	_	3,8
Akhalkalaki district	51	22	1	8,7	12	0,2	_	0,1	1	4,9	0	_	_	_	_	_	0,4
Akhaltsikhe district	41	4,2	1	28	6,6	0,4	0,3	1	0	16,6	0,1	_	_	_	_	_	0,6
Borjomi district	22	10	3	32	5,6	0,6	0,4	8,6	0	11,5	5,3	_	_	_	_	_	0,5
Kvemo Kartli	17	5,2	2	8,9	5,6	3,5	7,2	3,5	1	8,5	11,8	10,2	2,2	1	_	_	12,2
Bolnisi district	33	6,3	3	8,2	7	2,4	1,4	3,6	1	9,3	1,6	11,8	3,5	1,9	_	_	6,6
Gardabani district	20	6,7	3	15	9,1	6,3	5,9	5,7	1	16,7	0,8	3,3	3,4	1,2	_	_	1,8
Dmanisi district	5,1	1,7	1	7,4	0,8	0,1	0,4	0,2	0	2,1	81,5	_	0	_	_	_	0,1
Tetritskaro district	50	9,3	3	12	4,6	1,6	0,9	2	0	12,9	1,7	0,4	1,2	0,1	_	_	0,2

Marneuli district	16	4,7	1	4,5	4,1	2,6	11	2,9	2	3,9	1,1	18,6	1,9	1,1	_	_	24,7
Tsalka district	52	16	3	14	7,5	0,8	6,7	0,3	_	_	_	_	_	_	_	_	_
Shida Kartli	73	4,8	1	4,7	2	1	9,4	0,6	1	2	0,2	0,1	0,2	0	_	_	0,5
Gori district	77	5,3	0	3	1,5	0,9	9,8	0,4	0	0,7	0,1	0	0,1	0	_	_	0,4
Kaspi district	46	4,3	1	10	4,5	2,3	14	1,7	4	7,2	0,6	0,6	1,5	0,2	_	_	0,9
Kareli district	80	2,8	1	5,1	2,3	0,9	4,5	0,5	0	3	0,3	0	0	0	_	_	0
Khashuri district	19	4,6	2	41	2,9	1,4	1	6,1	0	15,2	0,7	0	0	0	_	_	5,9

To identify the available biomass waste amount for main crops by regions the main crops and area under these crops by regions have been defined. Walnut orchards are planted on 75,2% of Abkhazia AR (reported part); hazelnut makes 67.6% of fruit orchards in Adjara AR, 83.7% of fruit orchards in Guria and 60.3% of fruit orchards in Imereti; peach is the main fruit in Kakheti and it is planted on 66,5% of fruit orchards in there; the biggest part 20.4% of fruit orchards in Mtskheta-Mtianeti are plums; 35.7% of orchards in Racha-Lechkhumi &Kvemo Svaneti is covered by apple; 84.6% of orchard area in Samegrelo-Zemo Svaneti is planted under hazelnut; apple is the main fruit in Kvemo Kartli (17.3%) and Shida Kartli (73.5%) regions (Table IX).

Table IX. Orchard distribution by fruit varieties, % (regions)

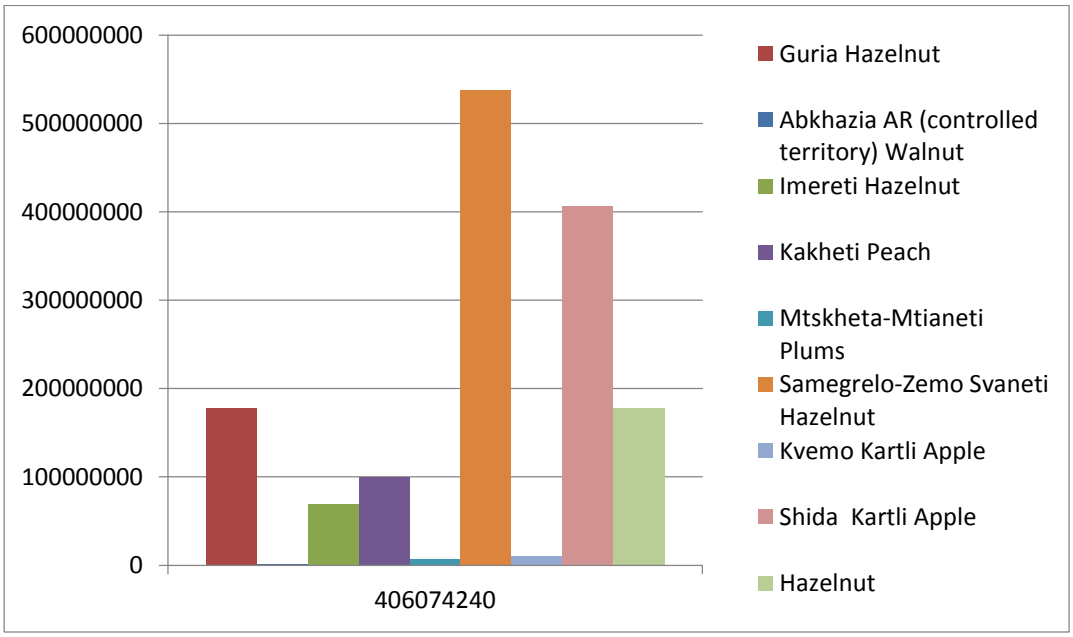
Location/fruit	Apple	Pear	Quince	Plums	Cherry (including sour)	Apricots	Peach	Sour plums	Cornel	Walnut	Hazelnut	Persimmon	Fig	Pomegranate	Kiwi	Feijoa	Mulberry
Abkhazia AR (reported part)	13	3,3	0,2	4,4	_	0,1	0,2	2,2	_	75,2	1,3	_	_	_	_	_	_
Adjara AR	9,4	4,7	0,4	1,9	0,8	0	0,4	2,1	0,1	9,7	67,6	1,9	0,5	0	0,3	0,3	0,2
Guria	2,3	3,1	0,1	0,3	0,6	0	0,7	1,9	0,1	3,5	83,7	1,7	0,5	0	0,3	0,9	0,1
Imereti	5,7	3,5	0,4	1,2	1,8	0,2	1,6	6,9	0,1	6,2	60,3	5,1	0,8	0,5	0	0	5,8
Kakheti	6	1,4	0,3	2,7	0,8	1,7	66,5	2,3	0,2	4	8,8	4,7	0,4	0,1	_	_	0.3
Mtskheta-Mtianeti	18,8	9,1	2,3	20,4	7,2	4,2	10,5	5,4	1	13,5	1,2	2,5	2,2	0,6	_	_	1,1
Racha-Lechkhumi &Kvemo Svaneti	35,7	7,7	1,4	12,8	3	0,2	3	2,2	0,1	29,2	2,8	0,7	0,6	0,1	_	_	0,4
Samegrelo-Zemo Svaneti	2,3	1,9	0,1	0,2	0,4	0,3	0,7	1,8	0,1	2,9	84,6	2,1	0,9	0	0,3	0,9	0,5
Kvemo Kartli	17,3	5,2	1,8	8,9	5,6	3,5	7,2	3,5	1	8,5	11,8	10,2	2,2	1	_	_	12,2
Shida Kartli	73,3	4,8	0,5	4,7	2	1	9,4	0,6	0,8	2	0,2	0,1	0,2	0	_	_	0,5

The main fruit orchards as the pruning residue resource have been defined by regions (Table X and Diagram VI). Reported part of Abrkazia AR can produce 807,500 GJ from walnut. Hazelnut pruning residues can be used as the bioenergy resource in Guria (177634,80 GJ), Imereti (69426,00 GJ), Samegrelo and Zemo Svaneti (538064,80 GJ) regions. Apple orchard's pruning residue can be used in Kvemo Kartli (10008,24 GJ) and Shida Kartli (406074,24 GJ). Plums – Mtskheta-Mtianeti (7308,00 GJ) and peach – Kakheti (99444,48).

Table X. Fruit Pruning Residue (GJ) energy potential of main fruit Orchards resourcesby regions

Region	Fruit	Area of fruit orchards, ha*	Average Residue from pruning** (kg/ha)	Average Heating Value, MJ/kg	Energy Production, MJ/ha	Total energy available, GJ
Abkhazia AR (reported part)	Walnut	25	1700	19	32300	807
Guria	Hazelnut	3339	2800	19	53200	177634
Imereti	Hazelnut	1305	2800	19	53200	69426
Kakheti	Peach	1824	2900	18,8	54520	99444
Mtskheta-Mtianeti	Plums	203	2000	18	36000	7308
Samegrelo-Zemo vaneti	Hazelnut	10114	2800	19	53200	538064
Kvemo Kartli	Apple	223	2400	18,7	44880	100084
Shida Kartli	ApplePear	90487	2400	18,7	448\80	406074

Diagram VI. Energy potential of main fruit orchard Residues, GJ by regions



Apple, pear, peach

Orchard fruit (primarily apples, but also significant quantities of pears, peaches) is grown by a big number of farmers on small plots in Shida Kartli and Racha-Leckhumi and Kvemo Svaneti regions, and are a significant source of household revenue. Orchards are increasingly unproductive and unprofitable due to the significant ages of the orchards, traditional growing methods, outdated varieties limiting fruit yields and market alternatives. There are 11 010 hectares of apple, 1 324 hectares of pear and 3 123 hectares of peach orchards in Georgia, grown primarily in two regions Shida Kartli, Kakheti and Rcha Lechkhumi and Kvemo Svaneti (Table XI, XII, XIII, XIV; Diagrams VII, VIII, IX). The amount of agricultural residues of fruit orchards pruning can be determined multiplying cultivation surface with a coefficient, which describes residues productivity (t/ha).

Table XI. Area under apple, pear and peach orchards in Georgia

A - Area of orchards, ha

B - Number of trees in orchards

C - Orchard's Density

	Apple			Pear			Peach		
Location, Region	A	B	C	A	B	C	A	B	C
Georgia, total	11010	2 57 299	214,11	1324	359 271	271,35	3 123	1295 345	414,78
Abkhazia AR, (reported part)	6	1 163	193,83	1	297	297,00	0	31	
Gulripshi district	6	1 163	193,83	1	297	297,00	0	31	
Adjara AR	45	19 114	424,76	19	9 524	501,26			
Keda district	18	5 846	324,78	5	2 010	402,00	2	1 189	594,50
Kobuleti district	1	303	303,00	2	721	360,50	0	134	
Shuakhevi district	21	10 959	521,86	9	4 750	527,78	1	234	234,00
Khelvachauri district	2	908	454,00	3	1 645	548,33	0	55	
Khulo district	2	1 098	549,00	1	398	398,00	1	745	745,00
Guria	111	29 450	265,32	152	40 119	263,94	0	21	
Lanchkhuti district	50	13 042	260,84	82	20 964	255,66	29	14 216	490,21
Ozurgeti district	37	10 354	279,84	48	13 357	278,27	17	8 002	470,71
Chokhatauri district	24	6 054	252,25	22	5 798	263,55	7	3 638	519,71
Imereti	130	39 720	305,54	84	24 354	289,93	5	2 576	515,20
Tkibuli district	12	2 145	178,75	3	726	242,00	27	17 994	666,44
Tskaltubo district	15	5 888	392,53	7	3 365	480,71	0	133	
Chiatura district	11	3 332	302,91	2	1 352	676,00	8	7 246	905,75
Bagdati district	4	1 070	267,50	5			1	742	742,00
Vani district	49	14 931	304,71	44	10 185	231,48	1	349	349,00
Zestafoni district	8	3 322	415,25	4	1 593	398,25	10	5 052	505,20

Terjola district	2	667	333,50	1	372	372,00	1	1 042	1042,00
Samtredia district	15	4 240	282,67	13	3 758	289,08	1	292	292,00
Sachkhere district	10	2 662	266,20	2	557	278,50	4	2 182	545,50
Kharagauli district	1	293	293,00	0	100		0	157	
Khoni district	3	1 170	390,00	2	819	409,50	0	15	
Kakheti	176	38 843	220,70	37	9 133	246,84	1 824	715978	392,53
Akhmeta district	19	5 634	296,53	3	1 175	391,67	16	7 064	392,53
Gurjaani district	31	7 149	230,61	5	579	115,80	1 498	595 56	441,50
Dedoplistskaro district	0	91		0	53		0	23	397,23
Telavi district	48	8 438	175,79	9	1 768	196,44	211	81 686	
Lagodekhi district	12	4 097	341,42	4	1 271	317,75	10	4 383	387,14
Sagarejo district	28	6 435	229,82	13	3 081	237,00	28	11 370	438,30
Signagi district	17	2 402	141,29	0	83		15	2 176	406,07
Kvareli district	21	4 597	218,90	3	1 123	374,33	46	14 220	145,07
Mtskheta-Mtianeti	186	62 533	336,20	90	30 125	334,72	91	57 399	309,13
Akhalgori district	14	6 518	465,57	7	3 548	506,86	2	1 465	630,76
Dusheti district	49	18 643	380,47	23	9 763	424,48	20	12 764	732,50
Tianeti district	39	12 641	324,13	10	3 257	325,70	0	33	638,20
Mtskheta district	84	24 719	294,27	50	13 557	271,14	69	43 137	
Kazbegi district	0	12		_	_				625,17
Racha-Lechkhumi &Kvemo Svaneti	94	26 691	283,95	17	5 764	339,06	6,00	3 747	624,50
Ambrolauri district	38	9 014	237,21	4	1 298	324,50			
Lentekhi district	2	941	470,50	0	85		1	641	
Oni district	10	3 567	356,70	4	1 457	364,25	0	53	
Tsageri district	44	13 169	299,30	9	2 924	324,89	0	251	
Samegrelo-ZemoSvaneti	269	93 030	345,84	226	78 721	348,32	4	2802	700,50

Abasha district	9	2 790	310,00	7	2 441	348,71	1	706	706,00
Zugdidistrict	164	53 248	324,68	141	46 606	330,54	53	29 662	559,66
Martvili district	9	3 734	414,89	9	3 843	427,00	4	2 655	663,75
Mestia district	9	2 343	260,33	4	1 072	268,00	0	13	
Senaki district	28	16 597	592,75	21	11 876	565,52	8	7 857	982,13
Chkhorotsku district	16	6 526	407,88	12	5 190	432,50	4	2 818	704,50
Tsalenjikha district	4	1 454	363,50	4	1 576	394,00	1	703	703,00
Khobi district	30	6 338	211,27	28	6 117	218,46	7	2 378	339,71
Samtskhe-Javakheti	722	146 953	203,54	73	21 207	290,51	6	2 734	455,67
Adigeni district	315	49 722	157,85	26	5 300	203,85	1	356	356,00
Aspindza district	98	26 295	268,32	17	6 361	374,18	3	1 652	550,67
Akhalkalaki district	19	6 612	348,00	5	2 840	568,00	_	_	
Akhaltsikhe district	290	64 111	221,07	25	6 611	264,44	2	720	360,00
Borjomi district	1	213	213,00	0	95		0	6	
Kvemo Kartli	223	68 122	305,48	55	20 312	369,31	110	46 884	426,22
Bolnisi district	35	8 507	243,06	7	1 660	237,14	1	627	627,00
Gardabani district	54	27 494	509,15	19	9 103	479,11	27	13 133	486,41
Dmanisi district	8	2 663	332,88	2	907	453,50	1	316	316,00
Tetritskaro district	4	1 305	326,25	1	240	240,00	0	39	
Marneuli district	119	27 957	234,93	26	8 341	320,81	80	32 727	409,09
Tsalka district	2	196	98,00	0	61		1	42	42,00
Shida Kartli	9048	1831680	202,44	570	119 715	210,03	951	388 381	408,39
Gori district	7141	1396916	195,62	484	95 346	197,00	748	291 427	389,61
Kaspi district	508	135 23	266,19	44	12 625	286,93	144	69 258	480,96
Kareli district	1361	293 250	215,47	35	10 260	293,14	57	27 148	476,28
Khashuri district	38	6 291	165,55	7	1 484	212,00	1	548	548,00

Table XII. Apple Orchard's resource for energy available from Fruit Pruning Residue (GJ) by regions.

Location, Region	Apple, ha	Average Residue (kg/ha)	Total Residue kg	Average Heating Value, MJ/kg	Energy Production , MJ/ha	Total energy available, GJ
Abkhazia AR, (reported part)	6	2400	14400	18,7	44880	269,28
Adjara AR	45	2400	108000	18,7	44880	2019,60
Guria	111	2400	266400	18,7	44880	4981,68
Imereti	130	2400	312000	18,7	44880	5834,40
Kakheti	176	2400	422400	18,7	44880	7898,88
Mtskheta-Mtianeti	186	2400	446400	18,7	44880	8347,68
Racha-Lechkhumi &Kvemo Svaneti	94	2400	225600	18,7	44880	4218,72
Samegrelo-ZemoSvaneti	269	2400	645600	18,7	44880	12072,72
Samtskhe-Javakheti	722	2400	1732800	18,7	44880	32403,36
Kvemo Kartli	223	2400	535200	18,7	44880	10008,24
Shida Kartli	9 048	2400	21715200	18,7	44880	406074,24

Diagram VII. Energy Resource from apple orchards' pruning Residue, GJ by regions

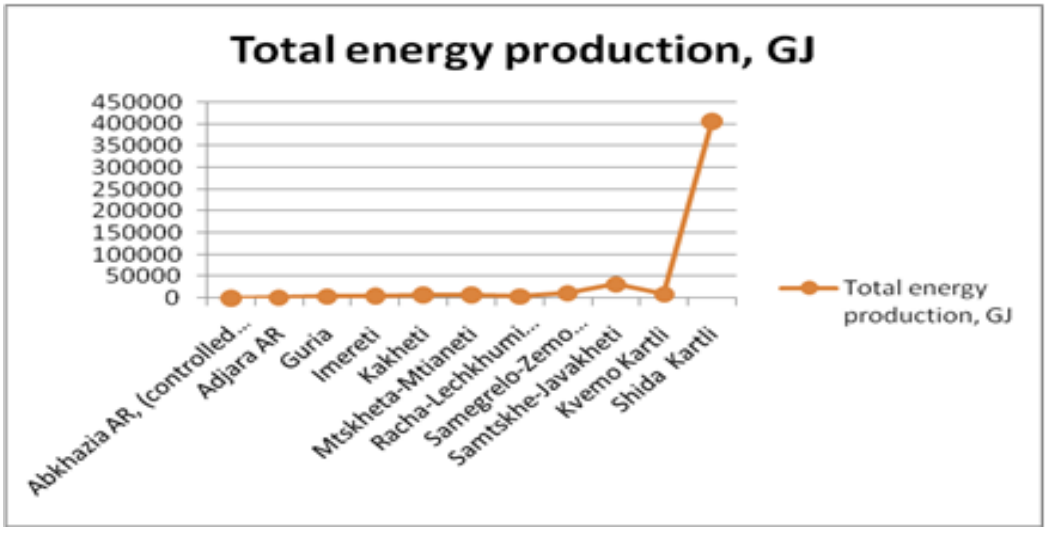


Table XIII. Pear Orchard's resource for energy available from Fruit Pruning Residue (GJ) by regions

Location, Region	Pear, ha	Average Residue ** (kg/ha)	Total Residue kg	Average Heating Value, MJ/kg	Energy Production, MJ/ha	Total energy available, GJ
Abkhazia AR, (reported part)	1	2000	2000	18,7	37400	37
Adjara AR	19	2000	38000	18,7	37400	710
Guria	152	2000	304000	18,7	37400	5684
Imereti	84	2000	168000	18,7	37400	3141
Kakheti	37	2000	74000	18,7	37400	1383
Mtskheta-Mtianeti	90	2000	180000	18,7	37400	3366
Racha-Lechkhumi&Kvemo Svaneti	17	2000	34000	18,7	37400	635
Samegrelo-ZemoSvaneti	226	2000	452000	18,7	37400	8452
Samtskhe-Javakheti	73	2000	146000	18,7	37400	2730
Kvemo Kartli	55	2000	110000	18,7	37400	2057
Shida Kartli	570	2000	1140000	18,7	37400	21318

Diagram VIII. Resource for energy available from pear orchards' pruning Residue, GJ by regions

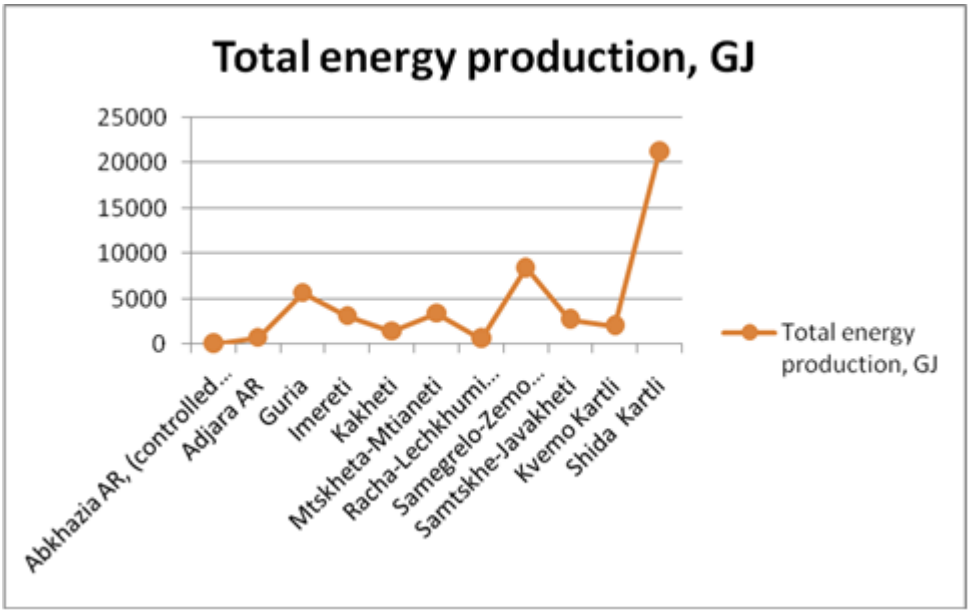
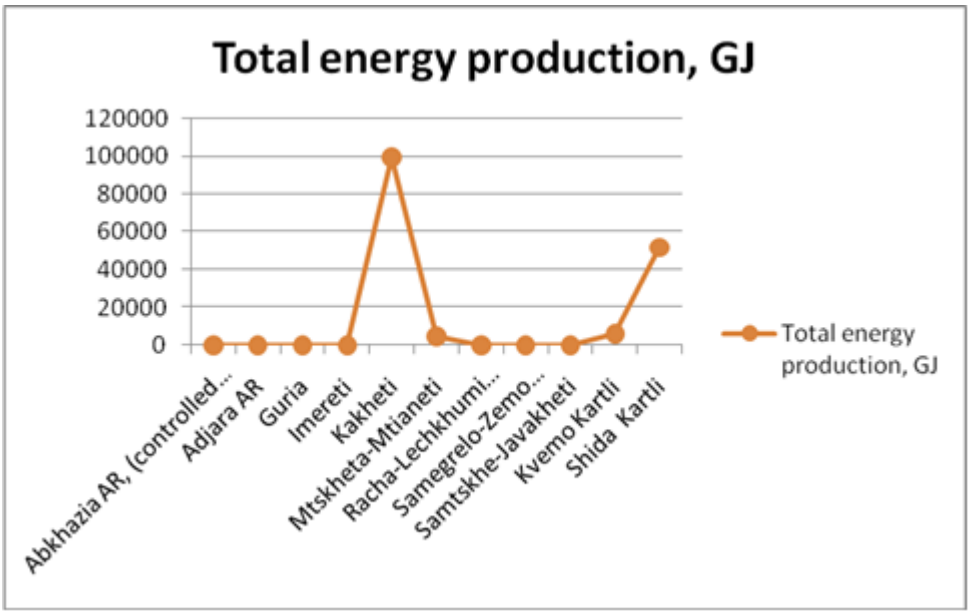


Table XIV. Peach Orchard's resource for energy available from Fruit Pruning Residue (GJ) by regions

Location, Region	Peach, ha	**Average Residue** (kg/ha)**	**Total Residue kg**	**Average Heating Value, MJ/kg**	**Energy Production, MJ/ha**	**Total energy** *available*, **GJ**
Abkhazia AR, (reported part)	0	2900	0	18,8	54520	0
Adjara AR		2900	0	18,8	54520	0
Guria	0	2900	0	18,8	54520	0
Imereti	5	2900	14500	18,8	54520	272
Kakheti	1 824	2900	5289600	18,8	54520	99444
Mtskheta-Mtianeti	91	2900	263900	18,8	54520	4961
Racha-echkhumi&KvemoSvaneti	6	2900	17400	18,8	54520	327
Samegrelo-ZemoSvaneti	4	2900	11600	18,8	54520	218
Samtskhe-Javakheti	6	2900	17400	18,8	54520	327
Kvemo Kartli	110	2900	319000	18,8	54520	5997
Shida Kartli	951	2900	2757900	18,8	54520	51848

Diagram IX. Resource for energy available from peach orchards pruning Residue, GJ by regions.



As the result of data analysis, apple orchard pruning highest residue (21 715 200 kg) and bio-energy resource (406074,24 GJ) are in Shida Kartli region; pear orchards' pruning highest residue (1 140 000 kg) and bio-energy resource (21318,00 GJ) - again in Shida Kartli region; peach orchards' pruning highest residue (5 289 600 kg) and bio-energy resource (99444,48 GJ) - in Kakheti region.

Many fruit (apple, pear, peach) growers in Georgia do not train their trees (pruning) after planting and neglect to annually prune the trees during the winter. Without training and pruning, apple trees will not develop the proper shape and form. A properly formed and shaped tree is necessary for optimal production of high quality fruit. Properly trained and pruned apple trees will also begin to yield fruit earlier in their lives and live significantly longer. Annual pruning is needed to remove dead, diseased, and broken limbs. Pruning also maintains the tree within its allotted space in the row and maintains adequate distance between the rows, allowing equipment to easily move through. Proper pruning will also open up the tree canopy in order to maximize light penetration. Light penetration is essential for flower bud development and optimal fruit set, flavor, and quality. Opening the tree canopy also permits adequate air movement through the tree, which facilitates leaf drying, allows for better crop protectant spray penetration, and reduces disease and insect pressure. To inform farmers regarding advantages of pruning will improve the orchards and give opportunity to use alternative energy to fruit-growers. Pruning will help to plant to grow better, accordingly – increase harvest. In addition, pruning would give high quality residue for energy use.

Hazelnut, Bay Leaf

Georgian hazelnuts present an excellent potential for growth, both in the processed nut segments and, thanks to the large size nuts of some Georgian varieties, the packed nut market segment. Currently, hazelnuts represent 24% (Geostat, 2013) of Georgian agricultural exports. Favorable microclimate, availability of land in production regions, presence of an experienced workforce, processing facilities and shipping infrastructure provide good basis for further improvements within the sector. Hazelnut orchards, as well as processing capacities, have grown intensely in Georgia reaching 40,000 tons of raw hazelnuts harvested annually or about 5% of world supply. Estimated number of hectares in cultivation is up to 15 000 hectares under hazelnut plantations (Geostat, 2013). Main hazelnut producer regions are Samegrelo-Zemo Svaneti (area – 10114 ha, Total Residue – 28 319. 2 t, Total energy production - 529 569,04 GJ), Guria (area – 3339 ha, Total Residue – 9 349, 2 t, Total energy production -174 830,04 GJ) and Imereti (area – 1305 ha, Total Residue – 3 654 t, Total energy production – 68 329,80 GJ) (Table XV, Diagram X).

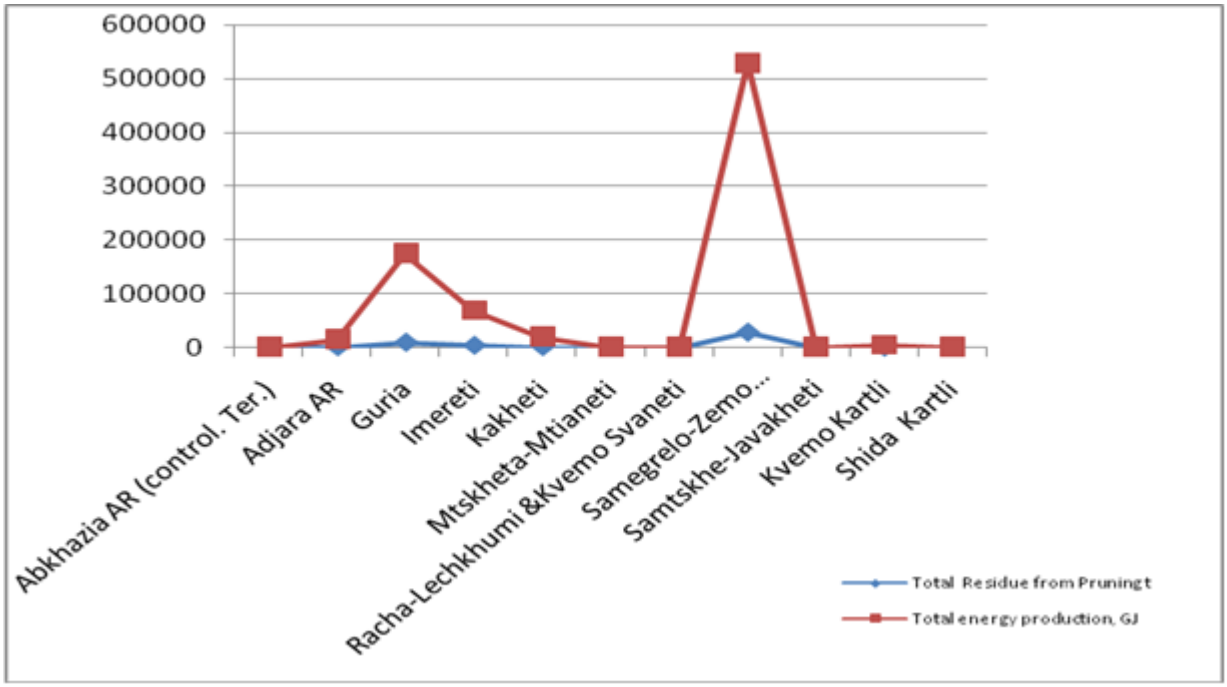
Table XV. Area under hazelnut orchards and average energy values of orchard pruning residues in Georgia

Location, Region, District	**Area of hazelnut orchards, ha***	**Number of trees in orchards***	**Number of trees in one ha orchard**	**Average Residue from pruning** kg/ha**	**Total Residue kg**	**Average Heating Value, MJ/kg**	**Energy Production, MJ/ha**	**Total energy available, GJ**
Georgia, total	15547	8583715	552,11	2800	43531600	18,7	52360	814040,92
Abkhazia AR, (reported part)	1	191	191,00	**2800**	2800	18,7	52360	52
Gulripshi district	1	191	191,00	**2800**	2800	18,7	52360	52
Adjara AR	275	227865	828,60	**2800**	770000	18,7	52360	14399
Keda district	5	4808	961,60	**2800**	14000	18,7	52360	261
Kobuleti district	256	209702	819,15	**2800**	716800	18,7	52360	13404
Shuakhevi district	0	488		**2800**	0	18,7	52360	0
Khelvachauri district	14	12720	908,57	2800	39200	18,7	52360	733
Khulo district	0	147		2800	0	18,7	52360	0
Guria	3339	1774761	531,52	2800	9349200	18,7	52360	174830
Lanchkhuti district	994	501578	504,61	2800	2783200	18,7	52360	52045
Ozurgeti district	1931	1032426	534,66	2800	5406800	18,7	52360	101107
Chokhatauri district	413	240557	582,46	2800	1156400	18,7	52360	21624
Imereti	1305	696490	533,71	2800	3654000	18,7	52360	68329
Tkibuli district	2	1445	722,50	2800	5600	18,7	52360	104
Tskaltubo district	292	57185	195,84	2800	817600	18,7	52360	15289
Chiatura district	2	1824	912,00	2800	5600	18,7	52360	104
Bagdati district	5	2865	573,00	2800	14000	18,7	52360	261
Vani district	532	370246	695,95	2800	1489600	18,7	52360	27855
Zestafoni district	77	38628	501,66	2800	215600	18,7	52360	4031
Terjola district	3	2303	767,67	2800	8400	18,7	52360	157

Samtredia district	320	179791	561,85	2800	896000	18,7	52360	16755
Sachkhere district	1	410	410,00	2800	2800	18,7	52360	52
Kharagauli district	1	629	629,00	2800	2800	18,7	52360	52
Khoni district	70	41164	588,06	2800	196000	18,7	52360	3665
Kakheti	388	95072	245,03	2800	1086400	18,7	52360	20315
Akhmeta district	6	1497	249,50	2800	16800	18,7	52360	314
Gurjaani district	12	5169	430,75	2800	33600	18,7	52360	628
Dedoplistskaro district	0	33		2800	0	18,7	52360	0
Telavi district	16	6654	415,88	2800	44800	18,7	52360	837
Lagodekhi district	46	12638	274,74	2800	128800	18,7	52360	2408
Sagarejo district	1	558	558,00	2800	2800	18,7	52360	52
Signagi district	0	48		2800	0	18,7	52360	0
Kvareli district	308	68475	222,32	2800	862400	18,7	52360	16126
Mtskheta-Mtianeti	13	6374	490,31	2800	36400	18,7	52360	680
Akhalgori district	0	425		2800	0	18,7	52360	0
Dusheti district	1	837	837,00	2800	2800	18,7	52360	52
Tianeti district	2	806	403,00	2800	5600	18,7	52360	104
Mtskheta district	10	4306	430,60	2800	28000	18,7	52360	523
Kazbegi district				2800	0	18,7	52360	0
Racha-Lechkhumi Kvemo Svaneti	5	3466	693,20	2800	14000	18,7	52360	261
Ambrolauri district	1	1342	1342,00	2800	2800	18,7	52360	52
Lentekhi district	0	28		2800	0	18,7	52360	0
Oni district	1	734	734,00	2800	2800	18,7	52360	52
Tsageri district	2	1326	663,00	2800	5600	18,7	52360	104
Samegrelo-Zemo Svaneti	10114	5684793	562,07	2800	28319200	18,7	52360	529569
Abasha district	137	61291	447,38	2800	383600	18,7	52360	7173

Zugdidi district	6279	3130173	498,51	2800	17581200	18,7	52360	328768
Martvili district	370	273984	740,50	2800	1036000	18,7	52360	19373
Mestia district	0	16		2800	0	18,7	52360	0
Senaki district	501	311921	622,60	2800	1402800	18,7	52360	26232
Chkhorotsku district	1178	850794	722,24	2800	3298400	18,7	52360	61680
Tsalenjikha district	1093	790984	723,68	2800	3060400	18,7	52360	57229
Khobi district	557	275630	494,85	2800	1559600	18,7	52360	29164
Samtskhe-Javakheti	2	1086	543,00	2800	5600	18,7	52360	104
Adigeni district	0	108		2800	0	18,7	52360	0
Aspindza district	1	530	530,00	2800	2800	18,7	52360	52
Akhalkalaki district	0	4		2800	0	18,7	52360	0
Akhaltsikhe district	1	361	361,00	2800	2800	18,7	52360	52
Borjomi district	0	83		2800	0	18,7	52360	0
Kvemo Kartli	88	76455	868,81	2800	246400	18,7	52360	4607
Bolnisi district	1	700	700,00	2800	2800	18,7	52360	52
Gardabani district	2	1798	899,00	2800	5600	18,7	52360	104
Dmanisi district	72	70559	979,99	2800	201600	18,7	52360	3769
Tetritskaro district	0	74		2800	0	18,7	52360	0
Marneuli district	12	3324	277,00	2800	33600	18,7	52360	628
Tsalka district				2800	0	18,7	52360	0
Shida Kartli	16	7162	447,63	2800	44800	18,7	52360	837
Gori district	6	2036	339,33	2800	16800	18,7	52360	314
Kaspi district	6	3083	513,83	2800	16800	18,7	52360	314
Kareli district	4	1654	413,50	2800	11200	18,7	52360	209
Khashuri district	1	389	389,00	2800	2800	18,7	52360	52

Diagram X. Resource for energy available from hazelnutorchards'pruning Residue, GJ by regions.

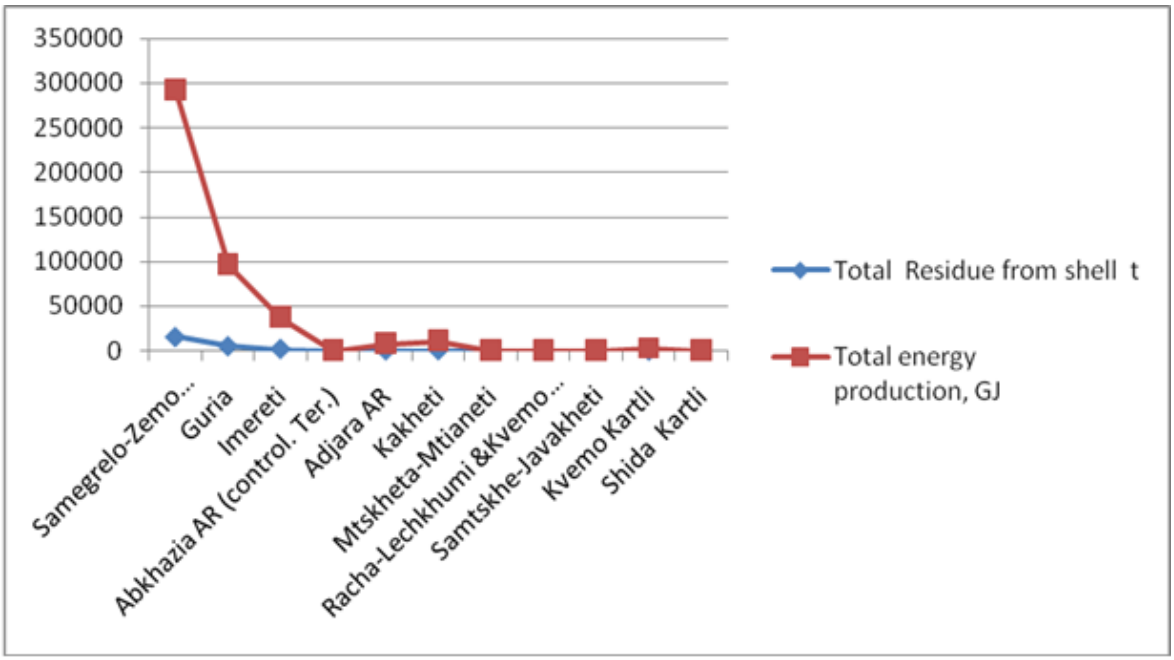


Hazelnut generates residues in the form of fronds and shells. About 10 fronds are shed per tree per year, yielding about 1.4 kg. dry woody biomass per tree or, assuming a density of 200 trees per ha, about 2,800 kg. per ha. However, no information is available on the amount of wood becoming available after replanting.

Table XVI. Average yield of hazelnut shells' residues in Georgia

Location, Region	Area of hazelnut orchards, ha*	Yield of hazelnut 1000 T*	Calculated yield according to area planted, 1000 T	Average Residue from shell kg/ha	Total Residue from shell according to area planted kg	Average Residue from shell according to yield %	Total Residue from shell according to yield, 1000 MT	Average Heating Value, MJ/kg	Energy Production, MJ/ha	Total energy avalable, GJ
Georgia, total	15547	39,7	38,87	1550	24097850	62%	24,10	18,7	28985	450630
Samegrelo-Zemo Svaneti	10114	20,5	25,29	1550	15676700	62%	15,68	18,7	28985	293154
Guria	3339	9	8,35	1550	5175450	62%	5,18	18,7	28985	96781
Imereti	1305	5,6	3,26	1550	2022750	62%	2,02	18,7	28985	37825
Abkhazia AR	1	4,6	0,00	1550	1550	62%	0,00	18,7	28985	29
Adjara AR	275		0,69	1550	426250	62%	0,43	18,7	28985	7971
Kakheti	388		0,97	1550	601400	62%	0,60	18,7	28985	11246
Mtskheta-Mtianeti	13		0,03	1550	20150	62%	0,02	18,7	28985	377
Racha-Lechkhumi &Kvemo Svaneti	5		0,01	1550	7750	62%	0,01	18,7	28985	145
Samtskhe-Javakheti	2		0,01	1550	3100	62%	0,00	18,7	28985	58
Kvemo Kartli	88		0,22	1550	136400	62%	0,14	18,7	28985	2551
Shida Kartli	16		0,04	1550	24800	62%	0,02	18,7	28985	464

Diagram XI. Resource for energy available from hazelnutShell Residue, GJ by regions.



Hazelnut shells are generally used as an alternative heating source in cities and suburban areas of Samegrelo and Guria Regions of Georgia, where most of the nuts are grown and harvested. Since hazelnut shells use to burn quickly, there is a need for air inflow regulation in order to burn them efficiently. This has stimulated deployment of efficient stoves in Samegrelo and Guria regions. The buyers of hazelnut require for hazelnut shell/product ratio not more than 60/40. Most hazelnut harvested in Georgia meets this requirement and shell part in hazelnut harvest is 62%. As mentioned above, average harvest of hazelnut is up to 40 000 ton/year. Accordingly, shell's residue would be up to 24 800 ton/year. About 1.55 ton dry shell residue becomes available per hectare per year.

Average Heating Value for hazelnut shell is 18.36 MJ/kg [20]. As main hazelnut producer regions are Samegrelo-Zemo Svaneti (Total Residue from Shell – 15 676. 7t , Total energy production – 293 154,29 GJ), Guria (Total Residue from Shell – 5 175. 4t, Total energy production -96 780,91 GJ) and Imereti (Total Residue from Shell – 2 022, 7t, Total energy production – 37 825,42 GJ), the same proportion of distribution biomass and energy production from shell were expected, that confirmed through analyze of data (Table XVI, Diagram XI). In the Table XVII are summarized total residue (kg) and energy production (GJ) from hazelnut sector in Georgian by regions. 67629, 4t biomass/1 264 670,71 GJ energy are available every year from hazelnut production in Georgia.

Table XVII. Average values of hazelnut residues in Georgia

Location, Region	Total Residue from Pruning t	Total energy available from pruning, GJ	Total Residue from shell t	Total energy available from shell, GJ	Total Residue t	Total energy available, GJ
Georgia, total	43531,6	814040,92	24097,85	450629,8	67629,45	1264670,72
Samegrelo-Zemo Svaneti	28319,2	529569,04	15676,7	293154,29	43995,9	822723,33
Guria	9349,2	174830,04	5175,45	96780,915	14524,65	271610,96
Imereti	3654	68329,80	2022,75	37825,425	5676,75	106155,23
Abkhazia AR (control. Ter.)	2800	52,36	1,55	28,985	2801,55	81,35
Adjara AR	770	14399,00	426,25	7970,875	1196,25	22369,88
Kakheti	1086,4	20315,68	601,4	11246,18	1687,8	31561,86
Mtskheta-Mtianeti	36,4	680,68	20,15	376,805	56,55	1057,49
Racha-Lechkhumi &Kvemo Svaneti	14	261,80	7,75	144,925	21,75	406,73
Samtskhe-Javakheti	5,6	104,72	3,1	57,97	8,7	162,69
Kvemo Kartli	246,4	4607,68	136,4	2550,68	382,8	7158,36
Shida Kartli	44,8	837,76	24,8	463,76	69,6	1301,52

Bay Leaf

Bay leaf quite popular crop grown for decades in Georgia, however, with the disintegration of the USSR, the resulting lack of capital and established market base, the Georgian bay industry went into an economic and cultural decline. Prior to that, Georgia was well known as producing premium quality leaves and oil to the market.

During last 2-3 years bay leaves have growing demand expressed by not only regional but, from the international market as well. Attractive prices give incentives to farmers to go back to bay leave growing operations; and private entrepreneurs to set up further value adding operations. According to information, provided by the information-consulting center of Abasha, MOA, more and more farmers are interested to start bay leave growing operation and/or improve production quality and volumes. Bay leaf is a traditional crop grown in Samegrelo-Zemo Svaneti region. While in the past bay leaf was in demand in the export and local markets, it is now grown mainly as a fencing hedge with the leaves sold locally as an herb. Due to its favorable climatic and soil conditions this plant is mainly spread in the western regions -Adjara,

Samegrelo, Guria and Imereti - of the county. Samegrelo is one of the major production regions with about 2500 tons of dried leaves that is equivalent to 5000 tons of raw leaves considering 1x2ratio). Totally up to 3000 ton of dried leaves are produced in Georgia. Generally, the current harvest is from unmanaged former plantations and small backyard plots. Nonetheless, exports appear to be slowly but consistently (2-3% per annum) increasing in recent years. However, no official information is available on the amount of area under bay leaf plantation in Georgia. It has been estimated that current exports from Georgia are around 3,000 T per year as compared to over 7,000 T per year two decades ago. Industry players indicate that Georgia has potential to produce up to 7-10,000 T of bay leaf per year. 6,000-6,700 trees are planted per hectare in bay leaf plantations. Planting scheme is 1.5mX1m. About 3 615 000 bay leaf trees are grown on up to 600 hectares. According the information, provided by MOAs regional consulting center in Khobi and farmers' information, the ratio for leaf and stems in bay wet leaf yield is 2:3. Based on this information have been calculated the following data:

1 tree provides 0.83 kg dried leaf;

1 ha – 5 ton dried leaf;

1 tree provides 2.5 kg wet stem;

1 ha – 15 ton stem.

Totally 9000 ton wet stems (average 7.2 ton dried) are available from bay leaf plantations per year in Georgia.

Georgian harvesting is done manually from early October through the end of March. The 2-year-old plants being harvested are cut near the base of the plant just above where lateral branches have established, roughly 6-8 centimeters above ground level. The cut of the branches should be clean and not to injure the plants ability to quickly rejuvenate growth. The entire branch of the plant is cut to ground level, bundled and tied, then stored and dried mainly per two years. Bay stems are kept there before sorting and defoliation. Depending on season, weather conditions and humidity content in the air drying in such location/ conditions may take from two weeks to five weeks. Defoliation is done manually.

9000 T residue of bay leaf is available totally in Georgia, which can be used as 171000,00 GJ energy resources. Most part of biomass from bay leaf 7500 ton is available in Samegrelo-Zemo Svaneti region.

Table XVIII. Area under bay leaf plantations and average values of plantations' pruning residues in Georgia

Location, Region/District	Area of bay leaf plantations, ha	Number of trees in plantation	Number of trees in one ha plantation	Average Residue (kg/ha)	Total Residue (t)	Average Heating Value, MJ/kg	Energy Production, GJ/ha	Total energy available GJ
Georgia, total	600	3615000	6025	15000	9000	19	285	171000
Samegrelo-ZemoSvaneti	500	3100000	6200	15000	7500	19	285	142500
Guria	100	515000	5150	15000	1500	19	285	28500

Available biomass – agro-residue and energy average values in regions of Georgia

Main crops' residue resource has been evaluated to define availability of biomass by way of agro-residue and define energy average values could be used as the alternative energy. Eight positions selected for study, based on the study–vine (vineyards' pruning residue), total fruit (fruits' orchards residue), hazelnut, bay leaf, apple, pear, peach and total and 11 regions have been (Tables XIX-XXX, Diagrams XII-XXIII).

Table XIX. Diagram XII. Total Available Agricultural Residue from Perennial Crops in Georgia

Crop	Total Residue (t)	Total energy production, GJ	Energy (TWh/year)
Vine	108515,1	2029232	0,563
Total Fruit	81373	1464724	0,406
Hazelnut	67629	1264670	0,351
Apple	26424	494128	0,137
Bay leaf	9000	171000	0,047
Peach	8691	163396	0,045
Pear	2648	49517	0,013
Total	304281	5636670	1,565

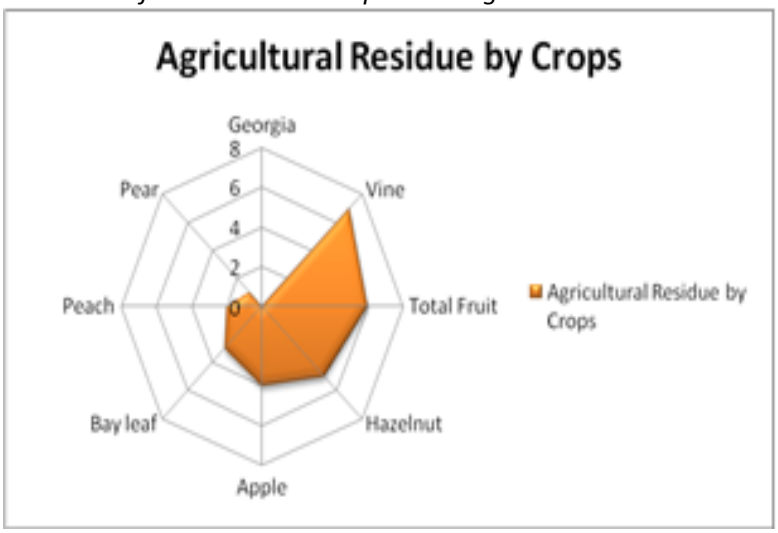


Table XX. Diagram XIII. Available residue from different crops in Adjara

Crop	Total Residue (t)	Total energy production, GJ
Hazelnut	1196,25	22369,87
Vine	121,8	2277,66
Apple	108	2019,60
Total Fruit	81,4	1465,20
Pear	38	710,60
Total	1545,45	28842,93

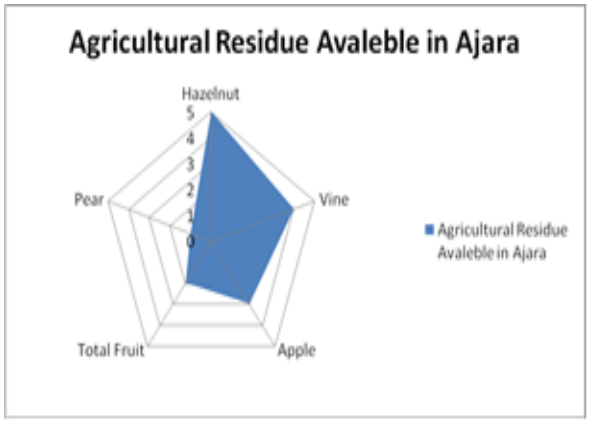


table XXI. Diagram XIV. Available residue from different crops in Guria

Crop	Total Residue (t)	Total energy production, GJ
Hazelnut	14524,65	271610,95
Total Fruit	8837,4	159073,20
Bay leaf	1500	28500,00
Vine	777,2	14533,64
Pear	304	5684,80
Apple	266,4	4981,68
Total	26209,65	484384,27

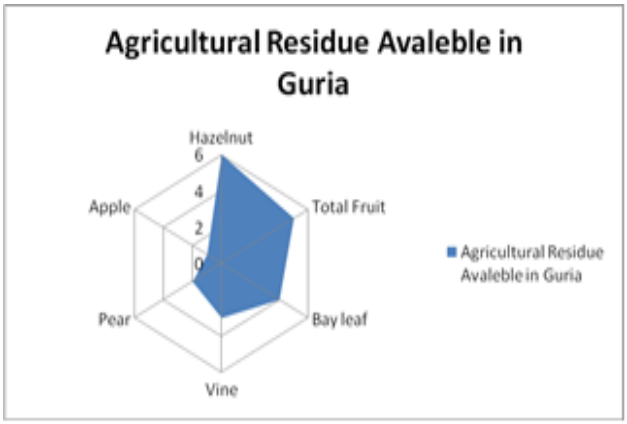


Table XXII. Diagram XV. Available residue from different crops in Imereti

Crop	Total Residue (t)	Total energy production, GJ
Vine	24893,6	465510,32
Hazelnut	5676,75	106155,22
Total Fruit	4483,6	80704,80
Apple	312	5834,40
Pear	168	3141,60
Peach	14,5	272,60
Total	35548,45	661618,94

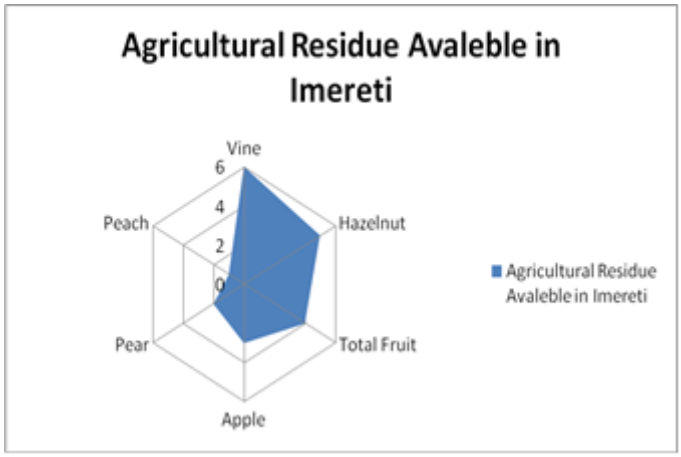


Table XXIII. Diagram XVI. Available residue from different crops in Kakheti

Crop	Total Residue (t)	Total energy production, GJ
Vine	64458,3	1205370,21
Total Fruit	6292	113256,00
Peach	5289,6	99444,48
Hazelnut	1687,8	31561,86
Apple	422,4	7898,88
Pear	74	1383,80
Total	78224,1	1458915,23

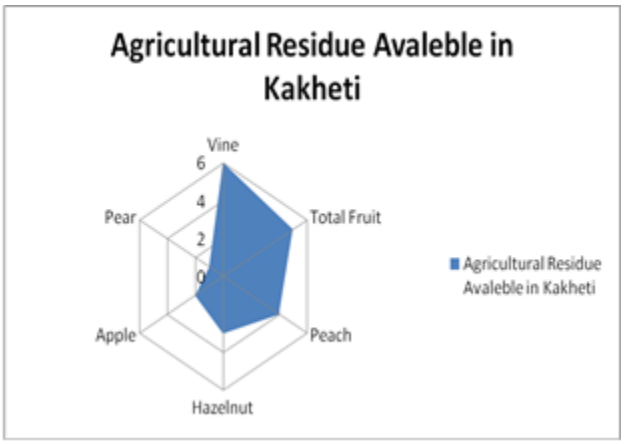


Table XXIV. Diagram XVII. Available residue from different crops in Racha-Lechkhumi &Kvemo Svaneti

Crop	Total Residue (t)	Total energy production, GJ
Vine	3909,2	73102,04
Total Fruit	277	5181,64
Apple	225,6	4218,72
Pear	34	635,80
Hazelnut	21,75	406,72
Peach	17,4	327,12
Total	4484,95	83872,04

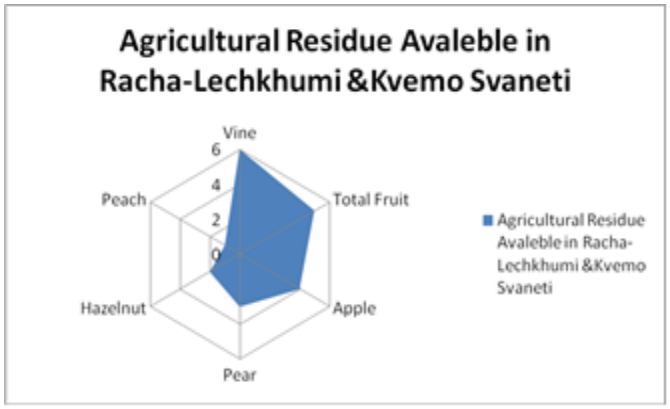


Table XXV. Diagram XVIII. Available residue from different crops in Samegrelo-Zemo Svaneti

Crop	Total Residue (t)	Total energy production, GJ
Hazelnut	43995,9	822723,330
Total Fruit	25715,8	462884,40
Bay leaf	7500	142500,00
Vine	2247,5	42028,25
Apple	645,6	12072,72
Pear	452	8452,40
Peach	11,6	218,08
Total	805686,4	205271,45

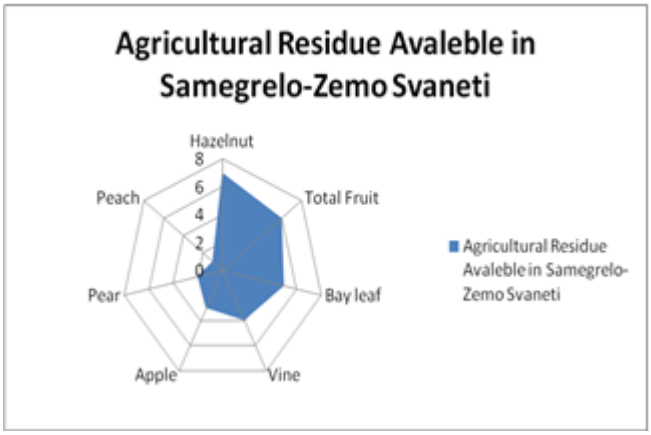


Table XXVI. Diagram XIX. Available residue from differentcrops in Samtskhe-Javakheti

Crop	Total Residue (t)	Total energy production, GJ
Vine	5095,3	95282,110
Total Fruit	2818,2	50727,60
Apple	535,2	10008,24
Hazelnut	382,8	7158,36
Peach	319	5997,20
Pear	110	2057,00
Total	9260,5	171230,51

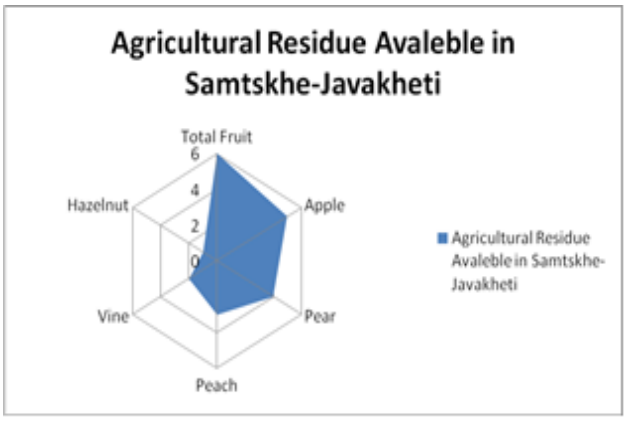


Table XXVII. Diagram XX. Available residue from different crops in Kvemo Kartli

Crop	Total Residue (t)	Total energy production, GJ
Total Fruit	1896,2	35460,68
Apple	1732,8	32403,36
Pear	146	2730,20
Peach	17,4	327,12
Vine	17,4	325,38
Hazelnut	8,7	162,69

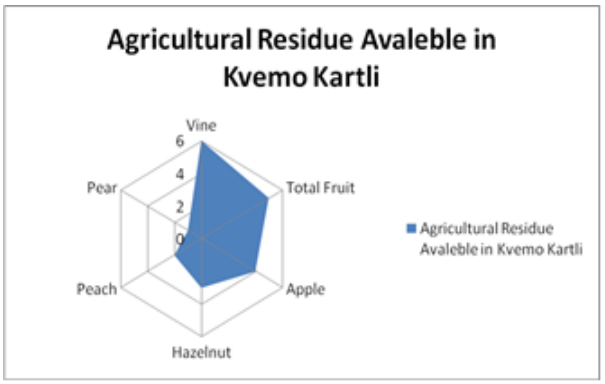


Table XXVIII.Diagram XXI. Available residue from different crops in Shida Kartli

Crop	Total Residue (t)	Total energy production, GJ
Total Fruit	26166,8	471002,40
Apple	21715,2	406074,24
Vine	4703,8	87961,06
Peach	2757,9	51848,52
Pear	1140	21318,00
Hazelnut	69,6	1301,52
Total	56553,3	1039505,74

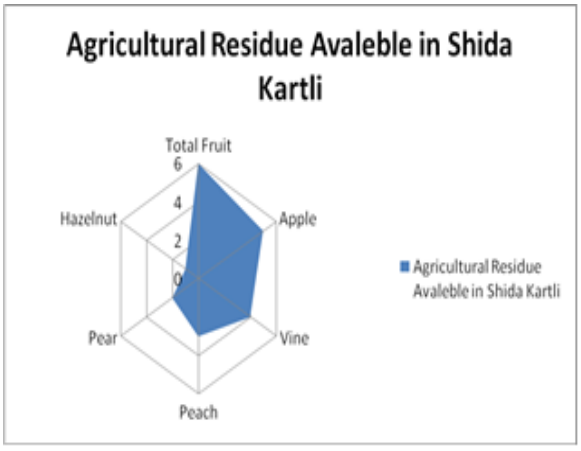


Table XXX. Diagram XXIII. Available residue from different crops in Abkhazia AR (controlled territory crops

Crop	Total Residue (t)	Total energy production, GJ
Total Fruit	81,4	1465,20
Apple	14,4	269,28
Hazelnut	4,35	81,34
Pear	2	37,40
Total	102,15	1853,22

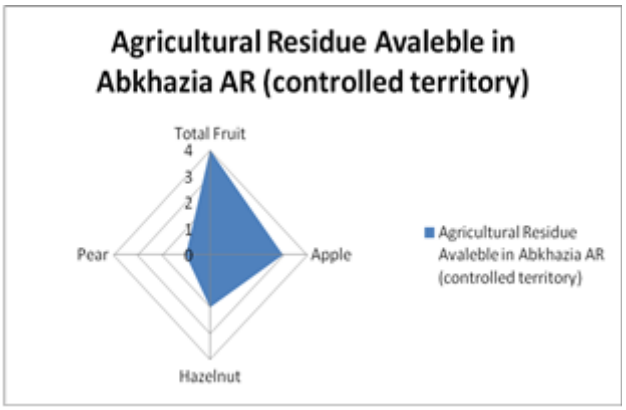
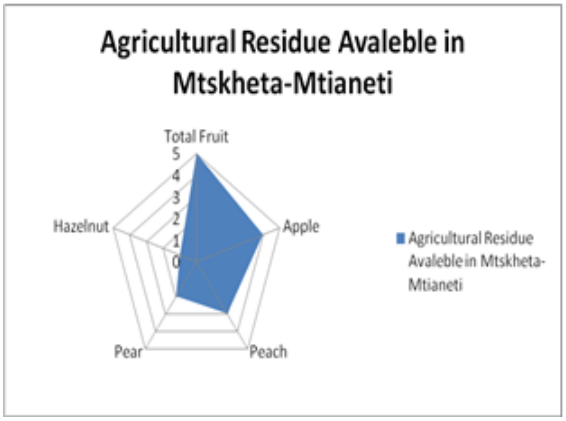


Table XXIX. Diagram XXII. Available residue from different crops in Mtskheta-Mtianeti

Crop	Total Residue (t)	Total energy production, GJ
Total Fruit	81,4	1465,20
Apple	14,4	269,28
Hazelnut	4,35	81,34
Pear	2	37,40
Total	102,15	1853,22



Conclusion

Total of 304Kt of agricultural residue, with 5.6 PJ (1.565 TWh)of annual energy resource is generetad in Georgia from perennial crops production(*Diagram XXIV- XXVII. Table XXXIII.*).

Through the analysis of fruit orchard structure in Georgia the following seven crops are identified as the main prunnig residue providers: grape, apple, peach, pear, hazelnut, bay leaf. All future activities are planned regarding the study of these seven crops (*Table IX, X*).

Samegrelo-Zemo Svaneti is the main biomass resourse provider in Georgia: 80 Kt agricultural residue, with 1,4 PJ energy production resources.

Through analysis of the data above, it is clear, that vineyards have the biggest part in agricultural residue of Georgia. Total Residue 108kt, with 2,0 PJ total energy resource is annually yelded in Georgia from established vineyards. There is a clear tendency to increase the area under grape plant; accordingly, through establishment of modern intensive vineyards the amount of produced biomass will increase.

Second in ranking of biomass residue production in Georgia are fruit orchards. Total Residue 81kt, with 1.5 PJ total energy resource is available in Georgia from fruit orchards.

The third biggest provider of agricultural residue in Georgia is hazelnut: Total Residue 68kt, with 1.3 PJ total energy resource.

Fruit orchards are the main agricultural residue providers in Abkhazia AR reported part) and the second agricultural residue provider for Samegrelo-Zemo Svaneti region. Total Residue 81,4 t, with 1465,20 GJ total energy resource is available in Abkhazia from fruit orchards and Residue 25715,8 t, with 0.5 PJ total energy resource in Samegrelo.

Hazelnut is the main agricultural residue resource in Ajara, Guria and Samegrelo-Zemo Svaneti regions. Total Residue 1196,25 t, with 0.02 PJ total energy resource in Ajara; total Residue 14524,65 t, with 0.3 PJ total energy resource in Guria are available from current hazelnut orchards' total Residue 43995,9 t, with 0.8 PJ total energy production resource in Samegrelo-Zemo Svaneti are yelded from current hazelnut orchards. Because of high export demand for local hazelnut, the orchard area will increase; accordingly, through establishment of new orchards available biomass will increase. Hazelnut shells are generally used as an alternative heating source in Adjara, Guria and Samegrelo Regions, where most of the nuts are grown.

Vineyards have main potential in agricultural residue of Imereti, Kakheti,Racha Lechkhumi and Kvemo Svaneti and Kvemo Kartli regions. Total Residue 24893,6t, with 0.5P GJ total energy resource is yelded in Imereti from current vineyards. Three times more biomass is yelded in Kakheti region: total Residue 64458,3t, with 1.2PJ total energy yelded.Racha Lechkhumi and Kvemo Svaneti produce total Residue 3909,2t, with 0.047 PJ total energy production resource. Kvemo Kartli yeldof total Residue is 5095,3t, with 0.1 PJ total energy production resource.

Vineyard pruning residue is not used as an alternative heating source on considerable scale. Most of the residues are left in the field or burnt. According to information, provided by farmers, the transportation and storage costs are much higher for local farmers, then value of alternative heating resource.

Samegrelo-Zemo Svaneti is known as the main producer and exporter of bay leaf. Main biomass provider for agricultural residue from bay leaf plantation is Samegrelo. Total Residue 7500 t, with 0.1 PJ total energy production resource can be available in Samegrelo-Zemo Svaneti from current bay leaf plantations. According to information, provided by MoA Consulting Centers in Samegrelo, bay leaf residue is not used as an alternative heating source by local farmers. Assimilation of bay leaf residue is difficult without cutting the stems, because bay leaf is ether bearing plant and its stems contains high quantity of ether-bearing oil. Farmers, with access to cutting machinery use the bay leaf residue in the same cooker, which is used for hazelnut shells.

Apple, and total fruit orchards are the main resource of biomass for Shida Kartli, Mtskheta-Mtianeti and Samtskhe-Javakheti regions. Apple pruning technique is most common in newly established orchards in Shida Kartli. The following total residue and total energy production PJ are can be avalable from apple orchards for these three regions:Shida Kartli - 21kt; 0.4 PJ, Mtskheta-Mtianeti - 446,4 t; 0.08 PJ and Samtskhe-Javakheti –1732,8 t; 0.03 PJ.

Main agricultural residue is not used as alternative energy resource in Georgia, because of high cost of biomass collection, transportation and storage. Local population mostly burns pruning residues directly in the field to prevent disease dissemination. The ash from burned stems is used as biological fertilizer in the orchards and vineyards. The main agricultural residue, used in Georgia is hazelnut shell.

Diagram XXIV Available residue and energy resource from different regions by crops in Georgia

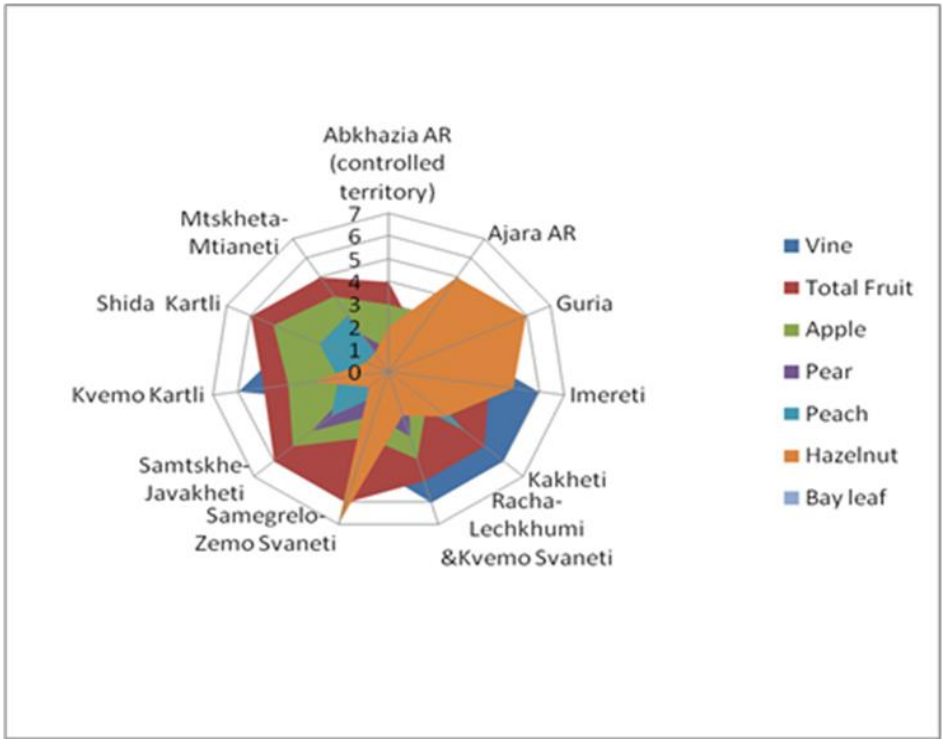


Diagram XXV. Available residue and energy resource from main crops by regions in Georgia

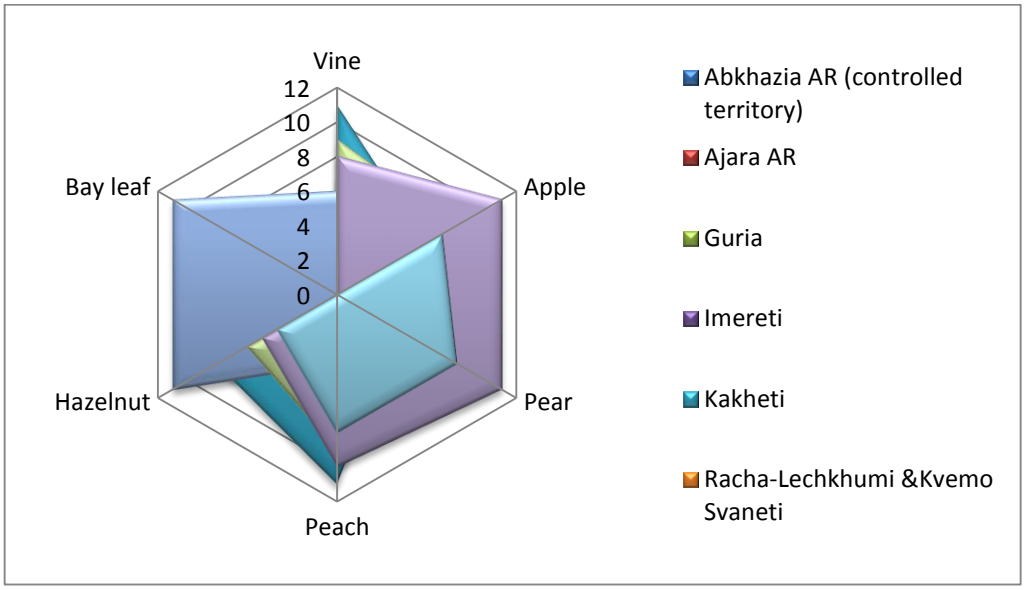


Table XXXI. Available residue and energy resource from different regions by crops in Georgia

Regions	**Crop**	**Total Residue (t)**	**Total energy available, GJ**
Abkhazia AR (reported part)	Total Fruit	81	1465
Ajara AR	Hazelnut	1196	22369
Samtskhe-Javakheti	Total Fruit	1896	35460
Mtskheta-Mtianeti	Total Fruit	2290	41223
Racha-Lechkhumi &Kvemo Svaneti	Vine	3909	73102
Kvemo Kartli	Vine	5095	95282
Guria	Hazelnut	14524	271610
Imereti	Vine	24893	465510
Shida Kartli	Total Fruit	26166	471002
Samegrelo-Zemo Svaneti	Hazelnut	43995	822723
Kakheti	Vine	64458	1205370

Diagram XXVi. Available biomass breakdown by main crops and by regions in Georgia

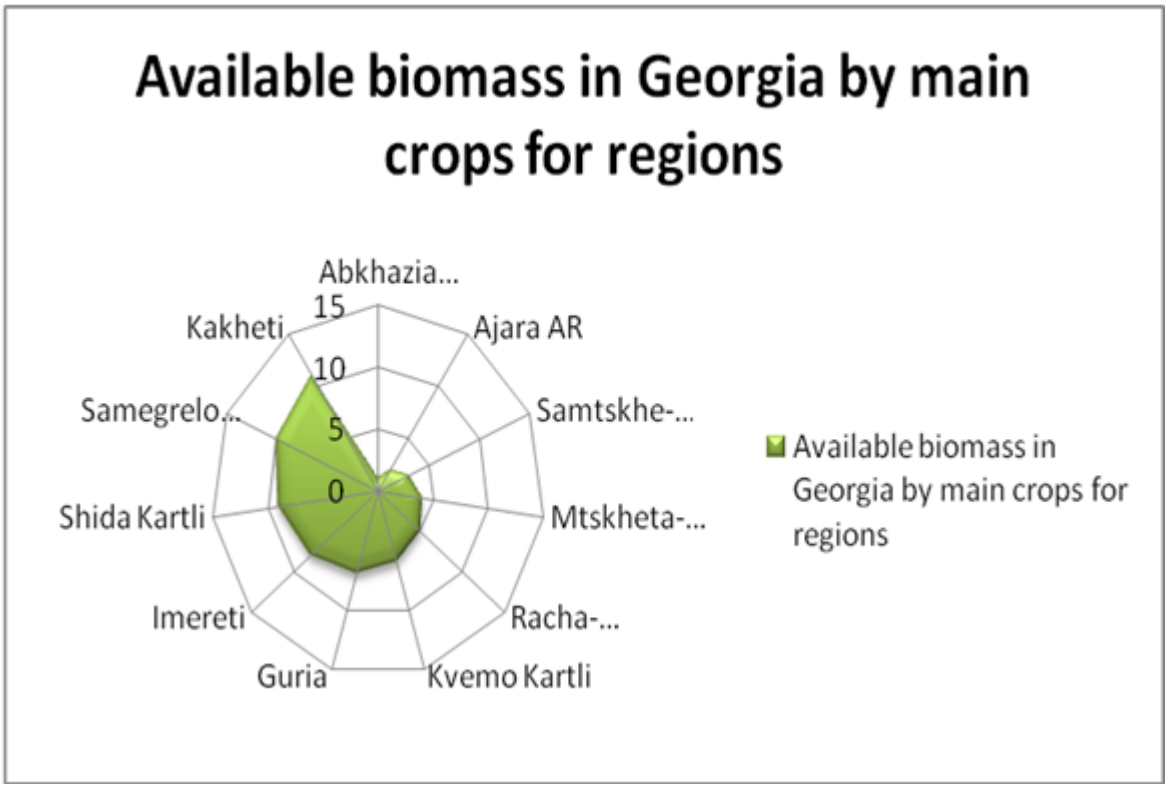


Table XXXII. Total Available Agricultural Residue from Perennial Crops in Georgia by Regions

Region	Total Residue (t)	Total energy production, TJ	Energy (GWh/year)
Abkhazia AR (reported territory)	102,15	1.9	0.51
Ajara AR	1545,45	28.8	8.01
Mtskheta-Mtianeti	3237,05	59.0	16.38
Samtskhe-Javakheti	3818,5	71.4	19.84
Racha-Lechkhumi &Kvemo Svaneti	4484,95	83.9	23.30
Kvemo Kartli	9260,5	171.2	47.56
Guria	26209,65	484.4	134.55
Imereti	35548,45	661.6	183.78
Shida Kartli	56553,3	1039.5	288.75
Kakheti	78224,1	1458.9	405.25
Samegrelo-Zemo Svaneti	80568,4	1490.9	414.13
Georgia	304281,45	5636.7	1565.74

Diagram XXVIi. Total Available Agricultural Residue from Perennial Crops in Georgia by Regions

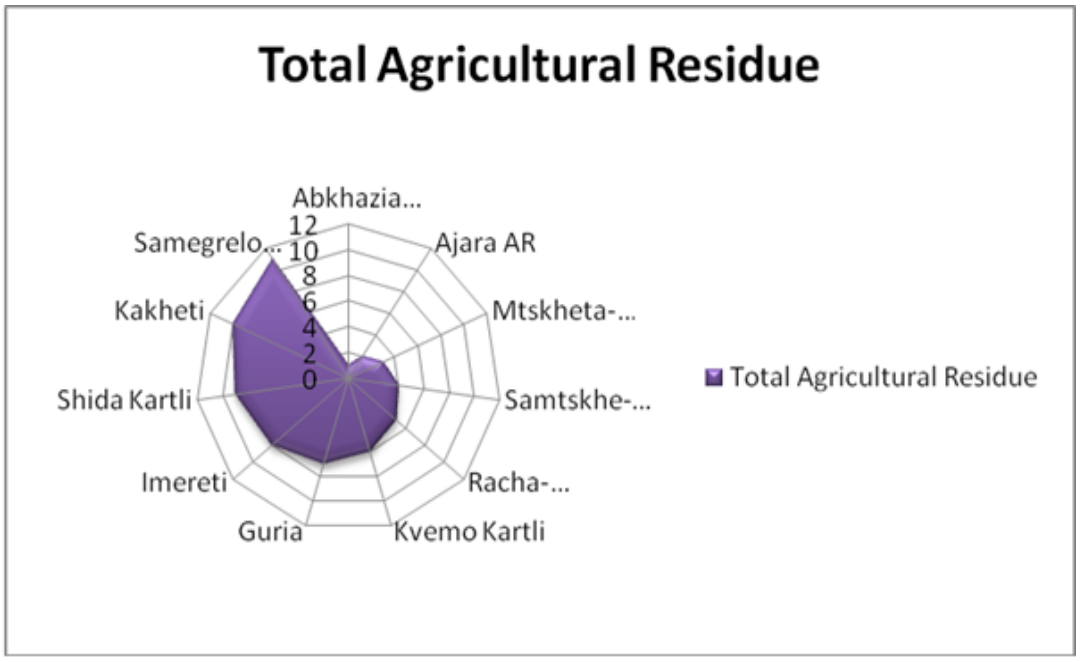


Table XXXII. Available energy from perennial crop residue in Georgia

Crop	Total energy potential, PJ	Total energy potential, TWh
Georgia	5.64	1.57
Vine	2.03	0.56
Total Fruit	1.46	0.41
Hazelnut	1.26	0.35
Apple	0.49	0.14
Bay leaf	0.17	0.05
Peach	0.16	0.04
Pear	0.05	0.01

Table XXXIII. Total Available Residue from Perennial Crops in Georgia by Regions

Region	Total Residue (t)	Total energy production, GJ	Energy (10^6 kWh/year)
Abkhazia AR (reported part)	102,15	1853,22	0,515
Ajara AR	1545,45	28842,93	8,012
Mtskheta-Mtianeti	3237,05	58956,08	16,377
Samtskhe-Javakheti	3818,5	71409,43	19,836
Racha-Lechkhumi &Kvemo Svaneti	4484,95	83872,04	23,298
Kvemo Kartli	9260,5	171230,51	47,564
Guria	26209,65	484384,27	134,551
Imereti	35548,45	661618,94	183,783
Shida Kartli	56553,3	1039505,74	288,752
Kakheti	78224,1	1458915,23	405,254
Samegrelo-Zemo Svaneti	80568,4	1490879,18	414,133
Georgia	304281,45	5636670,72	1565,741

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[20] The Utilization of Hazelnut Shell (Coryllus Avellana L.) Residues as Compressed Combustible Fuel Cengiz GÜLER1, Selim ŞEN2

Annual Crop Residual Biomass by Regions of Georgia

Biomass is considered as an emerging significant commercial energy source [1]. Besides the crops itself, large quantities of residues are generated every year from Rice, wheat, sugarcane, maize (corn), soybeans and groundnuts. These residues constitute a major part of the total annual production of biomass residues and can be an important source of energy for domestic as well as industrial purposes [2].

In 2013 a study was conducted by a group of experts from Georgian Technical University that is based on the statistical data of the 10 years (from 2001) of the State Department of Statistics. The study used a slightly different, methodology of assessing residue biomass energy potential for grain and bean crops and grassy plants.

Assessment of the residue biomass energy potential was conducted per individual crop and animal as well as for each Georgian region under the control of the central government. According to the research, the energy potential of residue biomass in Georgia is $7.7x10^6$MWh including equivalent of $1.1x10^6$ MWh from grain and bean crops and $6.65x10^6$MWh from animal residue. [3]

According to Geo Stat report [4] in 2013 the annual crops occupied310.7thd ha and shared 12% out of approximately 2.6 ml ha of agricultural land. The purpose of this study was to analyze the spatial potential of annual crop residues based on available statistical information by regions and then to convert into energy value. As an energy resource, annual crop biomass can either be used directly via combustion to produce heat, or indirectly after converting it to various forms of biofuel or combustible pellets and briquettes.

Crop residues are generally divided into two categories: field and process residues. Field residues are biological materials normally left in a field after the crop has been harvested. These field residues include stems, roots, leaves, and elements of the fruits (husks, cobs, pods, etc. that are not part of the harvested crop. Process residues are biological materials remaining after a crop has been converted into another form. Depending on the crop, these process residues can include pulp, peels, husks, seeds, bagasse and roots. Both field and process residues can be used as soil amendments and in animal feed. Some can be used in manufacturing. Straw and Stover are the most common field residues. Straw consists of the dry stalks of cereal plants (e.g., barley, oats, rice, rye and wheat) after the grain and chaff are removed. The leaves and stalks of corn, and bean plants left in the field after harvest comprise Stover. Field residues contain relatively little starch. The cellulose, hemicelluloses, and lignin they are less easily converted to biofuels than starches.

There are basically four uses for Stover, straw, and other crop residues: soil amendment, forage, feed, and bio refinery feedstock. Straw also is used for animal bedding. Left in place, the residue increases soil organic content, recycles soil minerals removed by the crop to the soil, and serves as a hindrance to erosion. When animals are allowed to graze on the residues, the amount of organic material returned to the acreage decreases somewhat, but the minerals are returned to the soil in a more soluble form.

Based on Geo Stat report [4] the study reviewed the agriculture residues in Georgia included straw of wheat and barley, corn Stover and cobs and kidney bean; (unfortunately the figures on the rest of annual crops were not broken down by regions and type of crops).

Methods and Materials

Study Area and Targeted Crops

Referring to Geo Stat reports, the study of agriculture residues included all 10 regions of Georgia during last 8 years through 2006 – 2013. The Geo Stat (Official statistics department) reported annual crop production through all 10 regions by type of crops as follows: Wheat, Barley, Corn and Kidney Been. The Vegetables and Melons were reported in general and not by type of crops. This was the main cause to avoid the study of those crops

Potential Crop Residues in Georgia

The most important existing basic annual crops in terms of residues in Georgia are wheat, barley, corn, beans, vegetables and melons, sunflower, etc. The rest of annual crops valuable as biomass residues like Rape and Sorghum were produced in the past 25 years ago, but not nowadays. The sunflower is being produced basically in Kakheti regions (Signagi and Dedoplitskaro municipalities) but unfortunately not reported in GeoStat's figures.

Main Steps

The purpose of this research is to identify biomass potential, especially crop residue resources in Georgia by regions. In order to identify the existing annual crop residue reserves and potential, the several steps were made: The reports of Geo Stat figures were considered to analyze type of crops, crop production and sown areas by regions. Except of that the ratios RPR (residue to product ratio) and proportion due to crop residues per ha (straws, Stover, husks, corn cobs etc.) was identified and then converted in energy value in GWh/year.

Ratio research due to biomass per sown area

According to the different sources there are a several ways of calculating the ratios between grain-straw, straw – sown area etc. But actual amount of residues which arise in any place will depend upon the cropping patterns and yields. There are such big variations in these processes that any reliable generalization is impossible. Where possible, field checks should be carried out to determine the most appropriate value for a given crop and area. It should also be noted that the information provided here, only shows the gross amount of residues, which are generated in theory. In practice this amount is normally not available because of alternative use or harvesting practice.

RPR by "Agro power" [5] shows the comparison of the average grain and straw-yields of the most important energy crops as well as the corn-straw-proportion.

Table # 1 shows the Overview of RPR data obtained from various publications.

Sources	Wheat Straw	Barley Straw	Corn Stover	Corn Cob	Soybean straw
Vimal '79			2.00	0.30	
AIT-EEC '83			2.30		3.94
Barnard ea '85	1.00 - 1.66	0.60 - 1.75	1 – 1.3		
Massaquoi '90	0.70 - 1.80	0.60 - 1.80	1 – 0.85		
Desai '90	1.48	1.58	2.00 - 2.30	0.20-0.50	
Ryan ea '91	0.70 -1.80	0.60 - 1.80	1.00 - 2.50	0.20-0.50	
Bhattacharya ea '93					2.50 + 1.00

(Source: Agricultural and Forest Residues – Generation, Utilization and Availability) [5].

The table above indicates quite a wide range of differences between various sources and to come to some general unified figures is impossible. Except of that, those crops were absolutely different varieties and were produced absolutely different climatic conditions and to come to more objective and realistic results, the ideas of local experts[10] and experienced farmers, through discussions and interviews, were taken into account to define the commonly developed local type of crop production and residue ratio per Mt/ha.

The annual gross potential of crop residues were obtained by calculating the sown area of agriculture crops through the years of 2006 - 2013andthentranslated to residue-to-cropping-area (RCA) per Mt/ha.

As experts and farmers reported the wheat, barley and oat are providing 200 (+/- 20) pressed bales (16 kg +/- 2kg each) per ha equal to 3 Mt/ha straws on average after the harvest. After corn grain harvesting there is about 6 Mt/ha of stover and 20 % of corn cob residue from the grain yield. The kidney been residues amount to 1Mt/ha on average and sunflower 3.5 Mt/ha. The table # 3 shows the ratios of local different crop residues by area.

Table # 2 The RCA of targeted crop residues per tons/ha on average reported by the local Experts.

Crops	Residues per tons/ha
Wheat straw	3.0
Barley straw	3.0
Oat	3.0
Corn Stover	6.0
Corn Cob	0.9
Kidney been	1.0
Sunflower	3.5

[10]Local Georgian experts: Researcher Dr. Zurab JinJikhadze with 55 years of experiences working on corn breading; Researcher Dr. Zaur Julukhidze with 45 years experiences working on cereals production; Dr. Goderdzi Goderdzishvili with 50 years experiences working on different crop production.

Table # 3 indicates the RPR for different crops

	medium grain-yield t/ha	medium straw-yield t/ha	grain-straw-proportion
Wheat	6,5	5,2	1 : 0,8
Corn	6,8	8,9	1 : 1,3
Sunflower	2,5	10,2	1 : 4,1
Soya	3,5	2,3	1 : 0,6
Rape seed	3,5	10,1	1 : 2,9

(Source: Agro power) [5]

Corn is one of the crops widely grown by most peasant farmers. It is estimated that grain yields range between 0.2 and 2.7 t ha[6, 7] (FAO, 1983, 1986). Powell [8] estimated that the straw: grain ratio of maize was 2:1. This means that twice as much crop residue as grain is produce which could be a very important feed for the ruminants. E.

The table # 1 shows the ratios of local different crop residues by t/ha. In order to convert the obtained results of crop residues into energy potential the ratios per each crops were taken from the report of 'Agropower'[5]

Table # 4 on energy value ratio by the crop residues

Crops	Total heating value	
	kWh/kg	MJ/kg
Wheat straw	4.70	16.92
Barley straw	4.70	16.92
Corn Stover	4.92	17.71
Corn Cob	4.82	17.35
Kidney been	3.80	13.68

1 kWh = 3.6 MJ

Crop Analysis

Asmentioned above, several crops: wheat, barley, corn, kidney been, oat and sunflower were studied and analyzed by the regions according to GeoStat reports of 2006 – 2013.

Wheat

Wheat is the leading vegetable-protein resource for humans [9]. Like corn, wheat is an annual monocot. Wheat field residues are a byproduct of the production of wheat, and include the straw, the chaff, and the root system. Structurally and chemically, the residues are similar to corn Stover.

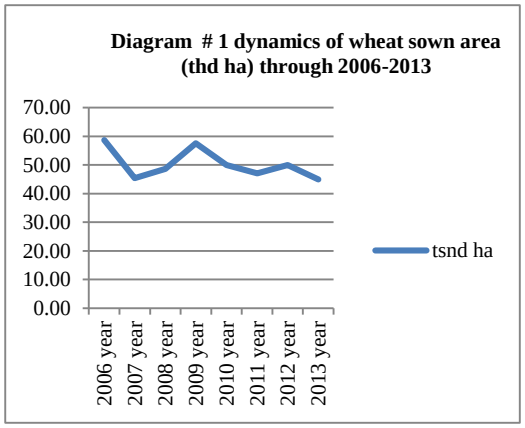
There are several registered varieties cultivated in all area of Georgia but basically the wheat is produced in East and Mid Georgia particularly in Kakheti, Kvemo Kartli and Shida Kartli regions. Wheat straw is mainly left in a field after harvesting or might be burnt in the field which is not recommended activity, because the land surface and soil fertility get degraded. In a best case the remained straws are pressed in bales and taken for animal feeding or for commercial purposes.

Due to GeoStat figures within those regions the most sown area was in 2006 around 58.7 thd ha[11], but since that time the cultivated area decreased to 44.9 thd ha in 2013. Totally the land under wheat varied between 44.90 – 58.70 thd ha within 2006 – 20013.

The table #5 on the dynamics of wheat development by sown area (tsnd ha) within regions through 2006 – 013

Regions / Years	2006	2007	2008	2009	2010	2011	2012	2013
Shida Kartli	7.4	2.9	8.2	13.3	8.4	12.9	5.6	3.00
Kakheti	36.4	37.1	29.2	35.8	30.8	22.5	30.8	33.70
Kvemo Kartli	11.1	3.9	7.2	5.9	8.5	8.1	9.5	6.30
The rest of Regions	3.8	1.5	4.0	2.5	2.3	3.5	4.1	1.90
Total	**58.70**	**45.40**	**48.60**	**57.50**	**50.00**	**47.00**	**50.00**	**44.90**

It is important to identify the places where the wheat mostly was cultivated and prioritized. According to sown area the wheat basically has been producing in Kakheti region 10 times more than in Shida Kartli and five times more than in Kvemo Kartly and covered 75 % of totally sown area in Georgia. Kakheti is famous as "Georgia's wheat warehouse" particularly Dedoplistskaro municipality. The last time in 2013 the wheat in Kakheti was sown in 33.7 thd ha little bit less than in 2006, 2007 and 2009. Based on diagram # 2 it is clear that Khakheti region contributed 75 % of all sown area in 2013.



[11]Annex #1Wheat residual biomass dynamics by regions

To follow statistics by sown area and to transform the figures into energy value the total amount of wheat residue made up 134.70 t/ha equivalent to 2.28 PJ/year. The Kakheti region was most valuable place for accumulation of biomass potential and theoretically generated 1.72 PJ/year.

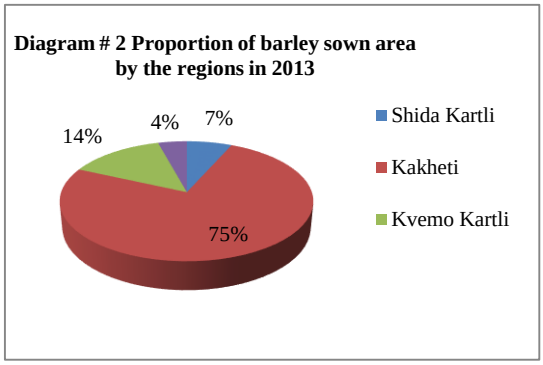
Table #6 indicates the potential of wheat residual biomass heating value PJ/year in 2013

Regions	Straw yield RPR by area t/ha	Heating value ratio MJ/kg	Straw yield by sown area 1000 t	Total Straw heating value PJ/year
Shida Kartli	3	16.92	9.00	0.15
Kakheti	3	16.92	101.10	1.71
Kvemo Kartli	3	16.92	18.90	0.32
The rest of Regions	3	16.92	5.70	0.10
Total			**134.70**	**2.28**

As an alternative use of wheat residue except of heating value, the straws are basically used for animal feeding intensively as one of the component of compound feed during the winter time. The current price of one bale is approximately 1.5 Gel/bale and there might be obtained 200 bales/ha (+/- 20 bale) equal to approximately 300 Gel/ha. To consider the wheat residues commercially as a fodder the total cost might reach to 40,410,000.00 Gel.

Barley

Barley a member of the grass family, is a major cereal grain[12]. It was one of the first cultivated grains and is now grown widely. Barley grain is a staple in Tibetan cuisine and was eaten widely by peasants in Medieval Europe. Barley has also been used as animal fodder, as a source of fermentable material for beer and certain distilled beverages, and as a component of various health foods. It is used in soups and stews, and in barley bread of various cultures. Barley grains are commonly made into malt in a traditional and ancient method of preparation.



Barley like the wheat basically is cultivated in East and Southern Georgia. It occupies the territory of Kakheti, Skhida Kartli, Kvemo Kartli and Samtskhe-Djavakheti[12]. In 2013 the

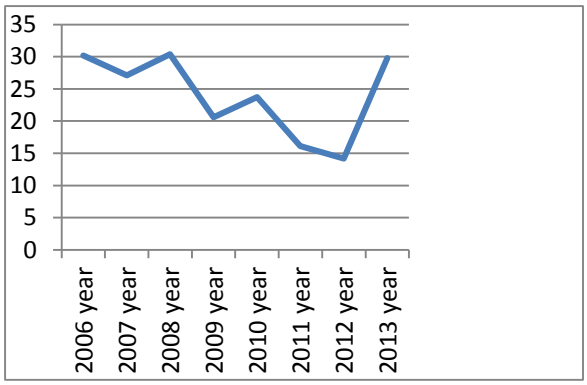
[12] Annex # 1Barley biomass dynamics by regions

most covered area by the barley was Kakheti and Shida Kartli and varied between 10 – 12 9 thd ha. Due to dynamics since 2006 the barley's most coverage territory reached to 30 thd ha was sown in 2006; 2008 and 2013, but the minimum sown area was defined in 2012 about 14 thd ha.

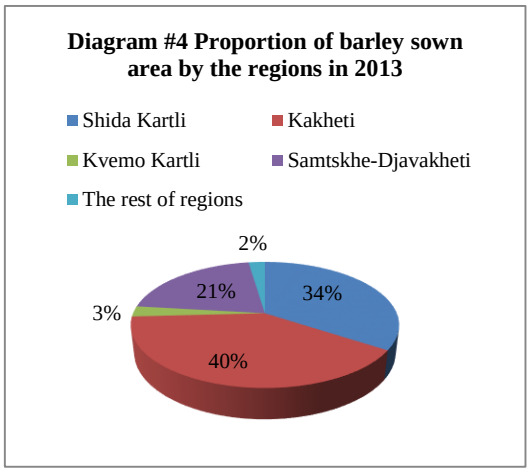
The table # 7. The dynamics of barley development by sown area (tsnd ha) within regions through 2006 – 2013

Regions / Years	2006	2007	2008	2009	2010	2011	2012	2013
Shida Kartli	3.5	4.6	3.2	4.8	4.3	4.9	4.4	10.2
Kakheti	10.9	10.3	16.0	8.1	10.3	4.3	4.8	11.9
Kvemo Kartli	3.9	1.1	0.4	1.3	0.3	1.0	1.7	0.8
Samtskhe-Djavakheti	11.3	10.7	10.4	5.9	8.8	5.8	2.9	6.2
The rest of regions	0.6	0.4	0.4	0.5	0.0	0.1	0.4	0.7
Total	**30.2**	**27.1**	**30.4**	**20.6**	**23.7**	**16.1**	**14.2**	**29.8**

The Diagram #3 Regarding to barley sown area through 2006 – 013.



To follow statistics the most cultivated area under the barley in 2013 was in Shida Kartli and Khakheti regions comparatively with 10 – 12 thd ha. and both regions shared 74 % of totally sown area. Regarding to straw energy potential, like the wheat it can generate 16.92 MJ/kg heating value and to refer to figures of 2013 it made up 1.5 PJ/year.



As an alternative use of barley straws except of biomass, the straw as one of basic component of fodder and used for animal feeding intensively during the winter time like a wheat and the price of one bale (16 kg) is little bit higher than wheat and makes up 2.5 Gel/bale equal to approximately 500 Gel/ha. To calculate these figures for through the season it might reach up to 14,900,000.00 Gel/year.

Corn

Corn is a large grain plant domesticated by indigenous peoples in Mesoamerica in prehistoric times. The leafy stalk produces ears which contain the grain, which are seeds called kernels [12]. Maize kernels are often used in cooking as a starch. Corn straw and stover are the most common field residues from crops. Straw consists of the dry stalks of cereal plants after the grain and chaff are removed. The leaves and stalks of corn left in the field after harvest comprise the stover. The distinction between the two appears to arise because straw is often removed from the field while stover is not as frequently removed. In many highly productive systems, particularly under continuous corn, corn stover production exceeds the minimum amounts needed to maintain soil health and productivity, making sustainable stover harvest viable. [10]

A substantial portion of the energy captured by crop plants remains in the straw or stover after harvest; stored primarily in cellulose, hemicellulose, and lignin. Based on relatively recent technological improvements, biological and chemical processes can be used to convert a fraction of this energy to biofuels. Corn straw in general provides good yields and combustion properties with the minor disadvantage that corn straw contains high water content at harvesting. Due to dry weather conditions, corn straw is used for different applications and also for energy production. Corn cobs are not only to serve as biomass for combustion but also for other applications like, litter for chicken and poultry production, litter for small animals (cats, dogs, reptiles,) and raw material for pharmaceutical and construction industry.

The corn residues including stovers, leaves and corn cobs represents most valuable crop as a biomass within targeted crops. The corn cobs as residues might be used for fuel consumption alongside with corn stovers. The corn is one of the important and highly valuable for the both as human as animal consumption in Georgia and is produced through all regions, but the most popular known in Western Georgia particularly in Imereti and Samegrelo regions where the sown area varies between 38 – 43 thd ha[13].

[13] Annex # 1 Corn Stovers dynamics by regions

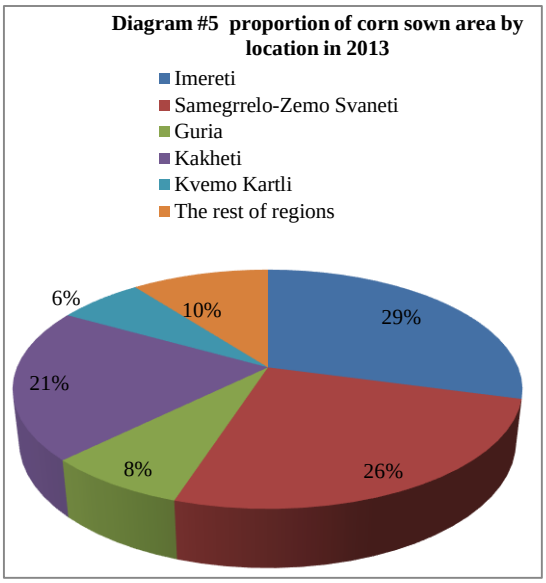
Table # 8 on the tendency of corn development (thd ha) through 8 years (2006 -2013)

Regions / Years	2006	2007	2008	2009	2010	2011	2012	2013
Imereti	45.80	44.60	45.70	44.90	37.00	39.10	35.30	43.90
Samegrelo-Zemo Svaneti	34.20	35.80	41.20	43.00	32.70	32.70	29.40	38.80
Guria	8.90	7.40	8.80	8.50	10.80	8.60	8.40	11.50
Kakheti	15.10	11.00	26.80	14.40	10.50	17.00	22.60	30.90
Kvemo Kartli	10.10	12.30	8.10	5.70	3.10	10.70	6.10	9.70
The rest of regions	15.00	14.40	15.60	13.60	14.50	13.10	13.00	15.60
Total	**129.10**	**125.50**	**146.20**	**130.10**	**108.60**	**121.20**	**114.80**	**150.40**

The highest coverage area by the corn was reported in 2013 which made up 150.4 thd ha but the minimum sown area was observed in 2010 about 108.6 thd ha.

In terms of location the most area by corn, as usual is produced in Western Georgia. It is very common and used as a main meal in Samegrelo so called “Gomi” , but in Imereti it is used in a backed style called as a ”Chadi”. To refer to statistics the most area is occupied by those regions and both made up the 55 % of total sown area in 2013.

Regarding to energy value, the both as corn stovers as corn cobs includes high energy ratio and each of them generated 15.98 PJ/year (corn stover) and 2.35 PJ/year[14] (corn cobs), totally 18.3 PJ/year in 2013.



[14] Annex # 1 Corn Cobs dynamics by regions

Table 9. Corn theoretical energy value in 2013

Regions	Straw RPR by area t/ha	Heating value ratio MJ/kg	Straw yield 1000 t	Total Straw heating value PJ/year	Corn cob yield RPR by area t/ha	Heating value ratio MJ/kg	Corn cob yield by 1000 t	Total Corn cob heating value PJ/year
Imereti	6	17.71	263.40	4.66	0.9	17.35	39.51	0.69
Samegrrelo-Zemo Svaneti	6	17.71	232.80	4.12	0.9	17.35	34.92	0.61
Guria	6	17.71	69.00	1.22	0.9	17.35	10.35	0.18
Kakheti	6	17.71	185.40	3.28	0.9	17.35	27.81	0.48
Kvemo Kartli	6	17.71	58.20	1.03	0.9	17.35	8.73	0.15
The rest of regions	6	17.71	93.60	1.66	0.9	17.35	14.04	0.24
Total			**902.40**	**15.98**			**135.36**	**2.35**

In terms of alternative use of corn residues, it might be more valuable as for heating material, especially in Western Georgia, because of high demand on corn residues as one of the main and basic fodder resource costs around 500 Gel/ha (0.5 Gel/pack; 1 pack includes 30 straws) and totally could reach to 75,200,000 Gel/year.

Kidney Been

Kidney Been is an annual leguminous dicot producing beans enclosed in pods [12]. Kidney beans are widely planted for its fruits and for the benefits to the soil arising from symbiotic nitrogen fixation that occurs in nodules formed on the roots of the plants. However, in as much as the beans are used in the rotation to improve soil nitrogen content, grazing of bean residues is far less common than grazing of corn stover and grain straw. Kidney bean residues have traditionally been incorporate into the soil to improve texture and mineral nutrient content.

Kidney Been is quite common crop in Georgia and basically shares great deal in a human meal, but for animals only residues might be used even in composition with the rest of fodder as one of the component. The biomass resource is comparatively low than the cereals. The basic sown area occupies Shida Kartli, Kvemo Kartli and Kakheti regions. According to dynamics of sown area since 2006 the lowest point was registered in 2009 about 5.5

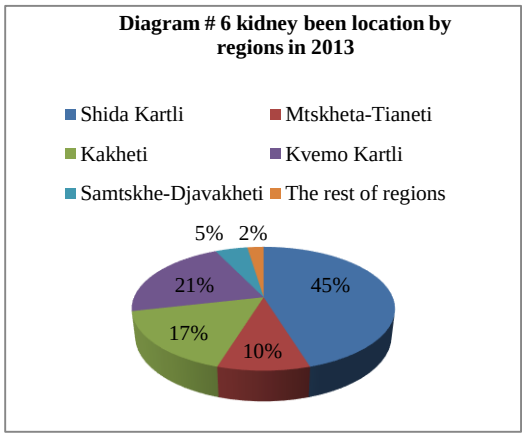
thd ha[15], but in 2013 the interest increased on kidney been demand and reached to 8.4 thd ha. That time kidney been mostly was cultivated in Shida Kartli around 3.8 thd ha.

The table # 10 regarding to kidney been development (thd ha) during 2006 – 2013

Regions / Years	2006	2007	2008	2009	2010	2011	2012	2013
Shida Kartli	3.0	2.6	3.9	2.1	1.8	2.0	3.0	3.8
Mtskheta-Tianeti	1.0	0.8	0.8	0.3	0.7	0.5	0.4	0.8
Kakheti	0.8	0.8	1.0	1.1	1.2	0.8	0.7	1.4
Kvemo Kartli	1.3	1.5	0.9	1.3	2.8	1.5	1.4	1.8
Samtskhe-Djavakheti	0.6	0.5	0.2	0.1	0.3	0.5	0.4	0.4
The rest of regions	0.5	0.5	0.5	0.6	0.4	0.7	0.5	0.2
Total	**7.20**	**6.70**	**7.30**	**5.50**	**7.20**	**6.00**	**6.40**	**8.40**

In terms of location kidney been mostly was consumed in Shida and Kvemo Kartli totally contributed 5.2 thd ha about 66 % out of 8.4 thd ha.In terms of residue energy value the energy potential is less compared to other crops. Totally it made up about 0.03 PJ/year.

Table # 11 on kidney been theoretically generated energetic value in 2013



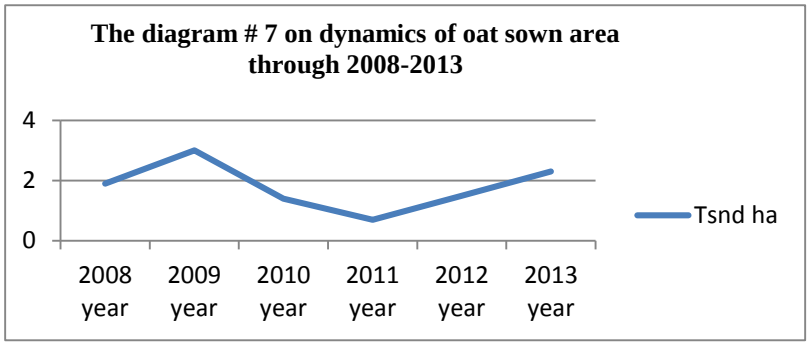
Regions	Residue RPR by area Mt/ha	Heating value ratio MJ/kg	Sown area 1000 Ha	Residue yield 1000 t	Total Residue heating value PJ/year
Shida Kartli	1	3.8	3.8	3.8	0.014
Mtskheta-Tianeti	1	3.8	0.8	0.8	0.003
Kakheti	1	3.8	1.4	1.4	0.005
Kvemo Kartli	1	3.8	1.8	1.8	0.007
Samtskhe-Djavakheti	1	3.8	0.4	0.4	0.002
The rest of regions	1	3.8	0.2	0.2	0.001
Total			**8.40**	**8.40**	**0.03**

Regarding to alternative use of residues some time it might be used included in animal feed as additional resource, but not as much as cereals or corn. Nobody collects it for commercial purposes but very seldom might be used for heating in case of the lack of other resources.

[15] Annex # 1 Kidney been residues dynamics by regions

Oat

The common oat is a species of cereal grain grown for its seed, which is known by the same name). While oats are suitable for human consumption as oatmeal and rolled oats, one of the most common uses is as livestock feed [12].



In Georgia it is produced basically in Khakheti region for animal feeding. To follow statistics of oat cultivation through 6 years within 2008 – 2013 the figures show that oat producing decreased from 3.0 thd ha to 2.3 thd ha. The dynamics on oat producing through 6 years is indicated in the diagram # 7.

In terms of energetic potential, according to RPR it is about 6.90 thd Mt and to convert into heating value ratio it made up 0.12 PJ/year.

Table # 12 on oat potential energetic value in 2013

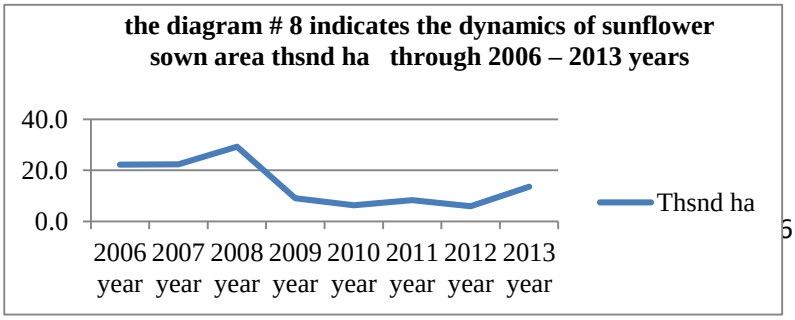
Regions	Residue (RCA) by area Mt/ha	Heating value ratio MJ/kg	Sown area 1000 Ha	Residue yield 1000 Mt	Total Residue heating value PJ/year
Total in Georgia	3	16.92	2.3	6.90	0.12

Sunflower

The domesticated sunflower is the most familiar species. Perennial sunflower species are not as popular for gardens due to their tendency to spread rapidly and become invasive. These are usually tall annuals, growing to a height of 50-390 or more cm.

The rough and hairy stem is branched in the upper part in wild plants but is usually unbranched in domesticated cultivars [9].

The petiolate leaves are dentate and often sticky. The lower leaves are opposite, ovate or often heart-shaped. The upper leaves are alternate and narrower. They bear one or several too many wide, terminal capitula (flower heads), with bright yellow ray florets at the outside and yellow or maroon disc florets inside. Sunflower which represents one of the important crops for human consumption as well as for biomass residue



(straws, husk etc.) in the eastern part of Georgia has the potential to yield 0.5–0.7Mt/ha seed yield [8] and it has less water, nutrient, and other input requirement than wheat [13].

According GeoStat report the sunflower most popular in Khakheti region and then in Kvemo Kartli. To follow figures (the diagram # 8) the dynamics of sunflower sown area decreased since 2008 from 29.3 thd ha to 13.5 thd ha in 2013. In Kakheti region the total area covered 28.8 thd ha and shared 98 % of totally sown area in 2008.

Dealing with energy potential, to calculate residue yield due to RCA for sunflower and convert into energy equitant the figures reach to 1.2 PJ/year.

Table #13 on sunflower theoretically generated energetic value in 2013

Regions	Residue by area (RCA) Mt/ha	Heating value ratio MJ/kg	Sown area 1000 Ha	Residue yield 1000 Mt	Total Residue heating value PJ/year
Kakheti	2.5	15.80	13.5	49.34	1.2

Conclusion

The annual crop residue biomass potential use can be considered for various purposes including animal feeding, heating, manufacturing industry, soil improvement etc. The diagram # 7 and shows, that the total sawn area under the studied annual crops in Georgia in 2013 reached 233 thd ha and was harvested as 1462.41 t /year. Within targeted crops the biggest area is occupied by corn fields 150.4 thd ha,or 64% of total sown area. Wheat and barley were cultivated on 74.2 thd ha and constituted 32 % of totally cultivated fields.

Table #14. The total sown area by crops in 2013

Regions	Wheat Sown area thsnd ha	Barley Sown area thsnd ha	Corn Sown area thsnd ha	Kidney been Sown area thsnd ha	Oat Sown area thsnd ha	Sunflower Sown area thsnd ha	Total thsnd ha
Imereti			43.90				43.90
Samegrrelo-Zemo Svaneti			38.80				38.80
Guria			11.50				11.50
Kakheti	33.70	11.90	30.90	1.4	2.30	13.53	93.73
Shida Kartli	3.00	10.20		3.80			17.00
Kvemo Kartli	6.30	0.80	9.70	1.80			18.60
Samtskhe-Javakheti		6.20		0.40			6.60
Mtskheta-Tianeti				0.8			0.8
The rest of regions	1.90	0.70	15.60	0.2			18.40
Total	44.90	29.80	150.40	8.40	2.30	13.53	249.33

The corn basically was grown in Imereti and Samegrelo regions totally covered 80.7 thd ha, while the wheat in Khakheti region occupied 33.7 thd ha and barley in Shiada Kartli and Kakhteti regions totally covered 22.1 thd ha.

Simultaneously, alongside with sown area the residue production contributed the same proportion within studied crops. The corn highest residue harvest reached to about 1037.76t/year, the wheat harvested in 134.70 t/year, the barley in 89.4 t/year and the kidney been around 8.40 t/year.

Regarding theoretical heating value all crop residues as potential heating resource could generate 25.49 PJ/year in 2013.

About the proportion within annual crops, the table # 15 and table # 16 show that corn residues both stovers and cobs have the highest potential and could generate 18.33 PJ/year or80% of total targeted crops' potential. The wheat reached to 2.28 PJ/year and contributed 10% when barley's energy value made up 1.51 PJ/year equivalent to 7%. The kidney been, oat and sunfower genereted the lowest energy value about 0.9 PJ/year around 3%.

The table # 15 on summurized figures of targeted crops' theoretical Residue yeald (thsnd Mt) by regions in 2013[16]

Regionsv/ crops	Wheat	Barley	Corn	Kidney been	Oat	Sunflower	Total
	Residue yeald 1000 Mt	Residue yeald 1000 Mt	Residue yeald 1000 Mt	Residue yeald 1000 Mt	Residue yeald 1000 Mt	Residue yeald 1000 Mt	Residue yeald 1000 Mt
Imereti			302.91				302.91
Samegrrelo-Zemo Svaneti			267.72				267.72
Guria			79.35				79.35
Kakheti	101.10	35.70	231.21	1.40	6.90	47.34	423.65
Shida Kartli	9.00	30.60		3.80			43.40
Kvemo Kartli	18.90	2.40	66.93	1.80			90.03
Samtskhe-Javakheti		18.60		0.40			19.00
Mtskheta-Tianeti				0.80			0.80
The rest of regions	5.70	2.10	107.64	0.20			115.64
Total	**134.70**	**89.40**	**1037.76**	**8.40**	**6.90**	**47.34**	**1342.50**

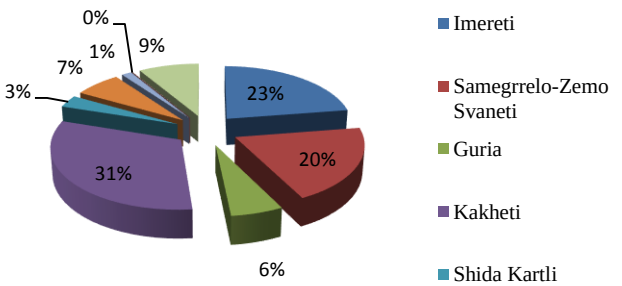
[16] Annex # 1

The table # 16 shows the summurized figures of targeted crops' energetc value in PJ/year by regions

Regionsv/ crops	Wheat	Barley	Corn	Kidney been	Oat	Sunflo wer	Total Energetic value PJ/year
	Energeti c value PJ/year	Energeti c value PJ/year	Energeti c value PJ/year	Energeti c value PJ/year	Energeti c value PJ/year	Energe tic value PJ/year	
Imereti			5.35				5.35
Samegrrelo-Zemo Svaneti			4.73				4.73
Guria			1.40				1.40
Kakheti	1.71	0.60	3.76	0.005	0.12	1.2	7.4
Shida Kartli	0.15	0.52		0.014			0.68
Kvemo Kartli	0.32	0.04	1.18	0.007			1.55
Samtskhe-Javakheti		0.31		0.002			0.31
Mtskheta-Tianeti				0.003			0.003
The rest of regions	0.10	0.04	1.90	0.001			2.04
Total	**2.28**	**1.5**	**18.3**	**0.03**	**0.12**	**1.2**	**23.4**

In terms of regional distrubution by residual biomass according to diagram # 10 the Kakheti region is most favorable where the production oa residue biomass ammounted 423.65 thsnd Mt, then the Imereti region could produce 302.91 thsnd Mt agricultrte waste. In samegrelo residues might be collected about 267.72 thsnd Mt, in Guria 79.35 thsnd Mt, in Kvemo Kartli 90.03 thsnd Mt, In Shida Kartli 43.40 thsnd Mt, in Samtskh-Javakheti 19.0 thsnd Mt and in Mtsketa-Tianeti 0.8 thsnd Mt. The rest of part Georgia could accunulate 115.64 thsnd ha.

The diagram # 10 shows the distribution of harvested crop residues thsnd Mt by regionms



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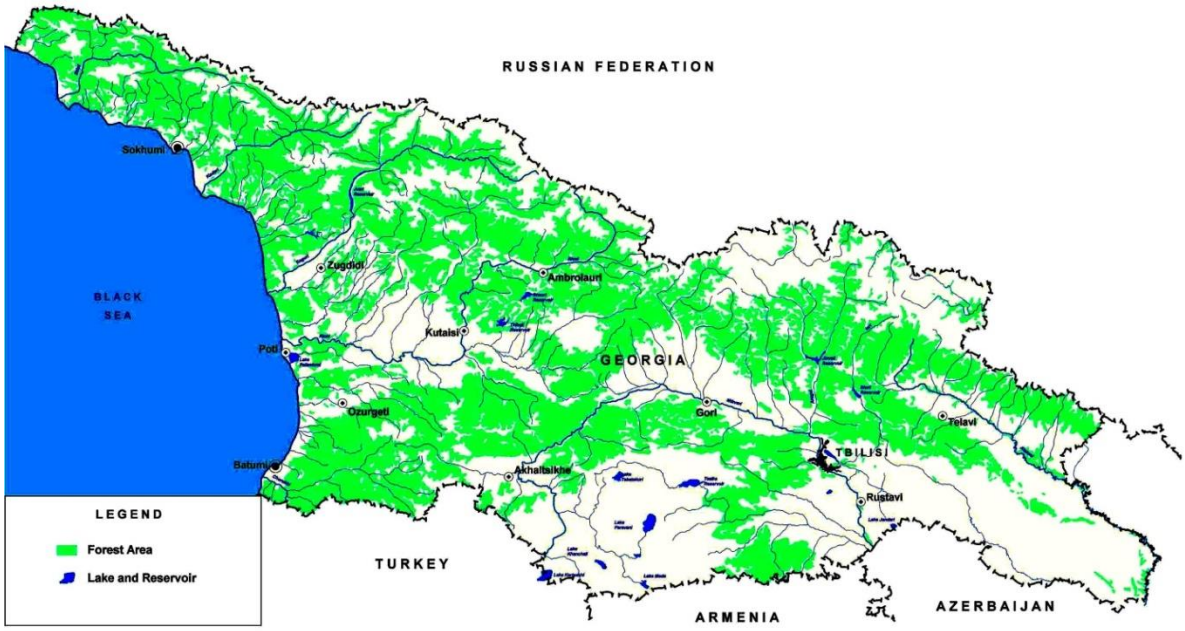
Wood waste and Alternative Woody Biomass Potential in Georgia

Background

Forests are one of the most valuable natural resources in Georgia. They occupy about 40% of the territory of the country and have an exceptional importance at national, regional and global level. Georgian forests not only conserve the unique biological diversity, but ensure continuous delivery of vital direct or indirect benefits and resources to the population. This in turn facilitates the development of different fields of industry, the growth of the well-being of the population, poverty elevation and creates favorable conditions for the sustainable development of the country [1].

Picture 1. Forests distribution in Georgia



According to forest statistics derived from different periods of forest inventory, the estimated total wood stock volume amounts to 451, 7 million m^3; the average annual increment of the wood is approximately 3.75-4, 5 million m^3.

On average per capita of forest is 0, 53 ha area, which is equivalent approximately to 80 m^3 of timber, and exceeds the average indicator of Europe three times. Average wood stock volume per hectare is 176 m^3, average age of Georgian forests is approximately 100-120 years, broad leave trees dominate comprising 80% of the forest, out of which up to 50% is beach.

Before 1950 Georgia harvested 1.5 million m^3timber per annum. Since 1950, Georgia's forests were included into category I, which by Soviet forest legislation prohibited forest cut for industrial needs, therefore the industrial felling volume, was reduced to 432 thousand m^3/annum. After independence (1990), the loss of cheap wood imports from Russia has significantly increased the pressure on Georgian forests, mostly for fuel wood and partly for high-quality timber for export.

Since independence, the absence of adequate forest reform, high demand on wood resources, incorrect planning and implementation of harvesting operations along with high level of illegal cut significantly devastated Georgian forests. The risk of further loss has considerably increased since 1999 when upon adoption of new forest code, the local population was officially allowed to undertake timber harvesting for own needs. Poor qualification and limited number of field staff of relevant forestry authorities makes it much more difficult to control the big number of people operating in forests. Entrepreneurs struggle to operate within the law because they face inadequate information on resources and inadequate license conditions. All of this has considerable adverse impact on forest ecosystems causing their degradation and in some areas even loss.

Therefore, it is the highest state priority to establish a system of forest management which may ensure forest protection and conservation along with efficient use of its economic potential. In this regard identification of alternative energy sources and establishment of clear and sustainable system of their supply to Georgian population may play a crucial role. Use of wood waste biomass is one of the important alternatives which may significantly substitute "live trees" and save Georgian forest ecosystems. At the same time this is innovative system may provide efficient and environmentally-friendly heating, reducing the use of fossil fuels and avoiding the greenhouse gas emissions. Recent National Forest Concept adopted by Georgian Parliament identifies these issues as one of the most important actions (see box 1):

Box 1. Extract from National Forest Concept (article 8.1) [1]

Provide affordable sources of energy to rural households and ensure their effective use, including by:

a) Assessing the potential for different types of energy sources to supply rural communities including introduction of high efficiency wood burning stoves, - insulation of houses, small scale combined heat and power generation, extending the gas network and elaborating action plans based on the findings from the assessment.

b) Development and implementation of firewood supply program for rural populations.

c) Rational use of firewood, use of dried wood, and reduction in the use of wood as a whole at the expense of other more effective alternatives.

Increase rural communities' sense of responsibility for their local forest resources, including by designing and piloting mechanisms for involving rural communities in the management of their local forests.

The objective of this study is an attempt to make a rough estimation of residual and alternative woody biomass potential accumulated in Georgia's forests as well as possible annual production from different types of forestry activities, identification of the sites with likely high concentration of alternative woody biomass and definition of the steps for more detailed assessment of its commercial utilization.

3.2. Review of existing studies and reports in the field of assessment of biomass potential in Georgia

There are several studies conducted in Georgia related to research of actual energy demand and possible supply alternatives including wood biomass. Some of them, focused on the assessment of biomass potential are highlighted below.

Pre-Feasibility Study on Producing High Efficiency Stoves, Fuel Pellets and Briquettes in Georgia, and Related Environmental, Social and Economic Benefits

Study was initiated by UNDP Country Office Georgia in 2006. Report contains information about existing level of wood harvesting in Georgia by regions, as well as assumptions on real use of fire wood by Georgian population and potential of biomass production. Table 1 and table 2 below shows the level of estimated timber harvest distributed by regions of Georgia:

Table 1. Annual timber harvesting in Georgia

Region	Liquid wood, Thousand cub.m	Industrial wood, Thousand cub.m
1	2	**3**
Adjara AR	84,7	**24,8**
Samegrelo-Zemo-svaneti	247,0	**109,5**
Racha-Lechkhumi	181,3	**74,8**
Imereti	152,0	**45,3**
Guria	98,1	**40,2**
Shida-Kartli	49,9	**13,9**
Mtskheta-Mtianeti	121,4	**38,9**
Samtskhe-Javakheti	191,9	**58,4**
Kvemo-Kartli	60,5	**10,7**
Kakheti	**176,8**	**59,3**

Table 2. Annual volume of fire wood production

Region	Production Volume Thousand cubic m.
Samegrelo-Zemo-svaneti	**49,0**
Racha-Lechkhumi	**48,0**
Imereti	**131,3**
Guria	**19,0**
Shida-Kartli	**40,0**
Mtskheta-Mtianeti	**70,5**
Samtskhe-Javakheti	**70,0**
Kvemo-Kartli	**50,2**
Kakheti	**80,0**
Total	**558,0**

Report provides some information about potential of wood waste biomass accumulated in forest and sawmills which might be found after completion of timber harvesting operations and primary wood processing. Distribution of this biomass is provided in Table 3.

Table 3. Wood biomass waste from tree cutting and processing[17]

Part of tree or product	Share, %
Left in forest:	
Top, branches and foliage	**23**
Stump (excluding roots)	**10**
Sawdust	**5**
Sawmilling:	
Slabs, edgings and off-cuts	**17**
Sawdust and fines	**7,5**
Various losses	**4**
Bark	**5,5**
Sawn timber	**28**
Total	**100**

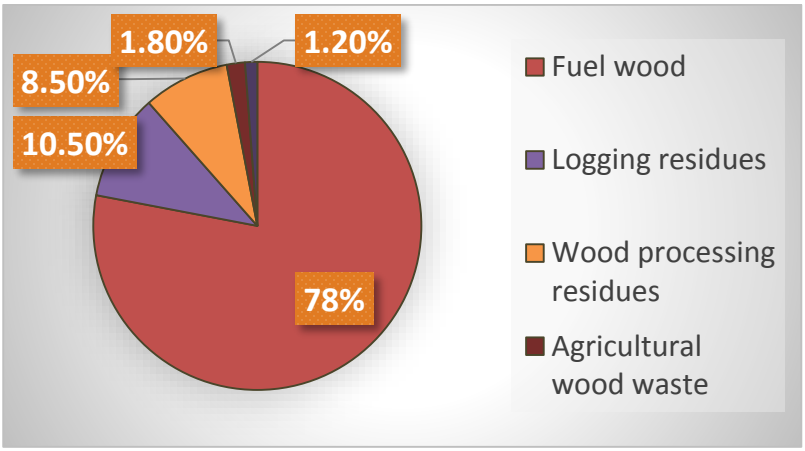
According to the Table 3, about 38% of wood waste biomass is left in the forest after tree cutting and 34% in sawmills after primary processing of round wood. Study also notes that there is potentially high amount of wood residues and sawdust deposits accumulated at all sawmill factories which are broadly distributed throughout of Georgia. [2]

[17]http://www.fao.org/docrep/t0269e/t0269e08.htm#TopOfPage

Potential of woody biomass in energy sector and their efficient use

Study was conducted in 2010 by NGO "Mountain 2002" based on USAID financial support within of project "Capacity Building of energy sector (ECI) in Georgia". According to the study, energy sources derived from wood are structured in the following manner (see Figure 1).

Figure 1. Structure of wood based energy sources



The study estimated annual wood biomass potential[18] accumulated after timber harvesting around 281 thousand m^3 and after primary wood processing - 228 thousand m^3. Total annual consumption of fire wood by Georgian population is estimated as 2, 5-3, 0 million m^3. [3]

Biomass fuel production and utilization legal review

Report is prepared under the UNDP project "Promotion of biomass production and utilization in Georgia" by legal expert Ms. Tamar Dugashvili in 2014 and is focused on existing legal conditions related to wood biomass. Main result of the study is that there is no legal definition of wood biomass in existing legal framework and no clear procedure how to acquire, obtain and process them. [4]

Recommendations to ensure efficient supply of population by energy sources

Study is conducted by CENN with financial support of Austrian Development Agency (ADA) in 2014 and provides recommendations to establish an efficient and sustainable system of energy supply in Georgia. Some of them are listed below:

Organizing of cleaning of forests where after felling operations significant amount of wood waste biomass is accumulated;
Development of forest tending operations in the forests where after felling operations much of dead and diseased trees are left;
Motivation of private sector to use wood waste biomass for production of wood pellets and briquettes.[5]

[18] Estimation is calculated for the year 2008.

GIZ study on fire wood concept in Georgia

Study was conducted by GIZ expert Wolfram Grunekle in 2012. The main recommendations of the study are focused on efficient use of forest thinning operations which will improve ecological conditions of forests and provide considerable amount of wood waste after timber harvesting. Study also recommends using dry fire wood instead of existing practice of using wet wood for heating which significantly reduces the energy efficiency. It also supports establishment of specialized trained groups composed of local population officially authorized to harvest and collect wood in forest instead of current practice of harvesting by individual villagers. [6]

Cadaster of Biomass Energy Potential of Georgia

The publication was prepared in 2013, under USAIDNATELI Project implemented by Winrock International .

The cadaster shows the scale and technical possibilities of using energy potential of different types of residue biomass in Georgian regions, assesses economic and competitiveness of its usage.

The publication estimates energy potential of wood in Georgian forests. The research is mainly concentrated on timber resources and does not include other types of biomass that can be found in the forest.

According to the study, 44 % of Georgian forest is located on the slopes with the inclination of 30 degrees or more, where wood collection is technically complicated. Annual growth of forests in Georgia is 3.6 mln m^3 and officially mandated felling is approximately 20% of the annual growth which can be used for energy purposes (for the mountainous areas like Samegrelo Zemo Svaneti, Racha Lechkhumi and Adjara this value is 10 %).

According to the research, energy potential of Georgian forests is 0,8 bln kWh. [7]

Conclusion for section 2

Following are key findings derived from existing studies related to the assessment of wood waste biomass in Georgia :

- Samegrelo-Zemo Svaneti is the region with the highest annual production of industrial wood;
- Imereti is the region with highest annual consumption of fire wood;
- About 38% of wood is left in forest as wood waste like tree top, branches and foliage, Stump (excluding roots) and sawdust;
- About 34% of wood waste is accumulated in sawmills like slabs, edgings and off-cuts, Sawdust and fines, bark and various losses;
- Some of 280 thousand m^3 of wood waste is left in Georgia forest every year after harvesting;
- Wood waste accumulated in sawmills[19] is estimated as 228 thousand m^3 .

3.3. Analysis of basic statistic information on total wood harvesting volumes in Georgia for the last 3-5 years

[19] Estimation includes amount of wood waste accumulated in previous years as well.

Wood waste Biomass produced through forestry is mainly of two origins: a) Biomass derived from timber harvesting and logging presented as tree top, branches and foliage, Stump (excluding roots) and sawdust, and b) The biomass resulting of primary timber processing at sawmills, presented as slabs, edgings and off-cuts, Sawdust and fines, bark and various losses. For the assessment of existing wood waste biomass and annual accumulation potential in Georgia forests there is a need to obtain and analyze the existing data on both: wood harvest and primary processing. Currently wood harvesting and processing operations are conducted by following legal and physical bodies: (i) forest use license holders; (ii) local population; (iii) wood processing factories/sawmills.

Forest use license holders

For the moment in Georgia there are 67 active forest use license holders which cover about 180 thousand hectares of forest and total wood volume to be harvested over the licensed period is 2 832 834 m^3 (list of wood harvest license holders provided in annex 1). Licenses are issued since 2006 for the different time period from 3 years up to 20 years which is shown in Table 4 below:

Table 4. Distribution of timber harvest volume by licenses

Validity of the license, Year	Area covered by licenses, Hectare	Annual harvest plan, m^3	Total timber volume to be harvested, m^3
20	107 386	118 799	2 375 980
10	32 390	34 189	341 893
5	20 886	18 430	92 150
3	342,9	3117	9 350
2	355	3894	7788
Total	**161 359,9**	**178 429**	**2 832 834**

There are also two special agreements and two licenses issued for private companies with the objective to improve ecological conditions of chestnut forest stands in Zestaphoni, Chiatura, Kharagauli and Tkibuli forests. Under this agreements companies are operating on about 20 000 hectares of forest[20].

Total timber volume to be harvested by license holders is distributed by regions of Georgia in the following way:

[20]These companies are responsible to undertake sanitary cut, that's why there are no preliminary fixed figures about volumes of wood might be felled.

Table 5. Distribution of timber harvest volume by regions

Region	Number of license holders	Timber harvest volume, m^3
Samegrelo Zemo Svaneti	29	1 027 513
Racha-Lechkhumi Qvemo Svaneti	6	103 183
Imereti	7	551 005
Guria	1	220 440
Mtskheta Mtianeti	4	213 556
Sida kartli	9	52 637
Kvemo kartli	-	-
Samtkhe Javakheti	6	57 840
Kakheti	5	606 660
Total	67	**2 832 834**

As it is seen from the Table 5, 29 companies are operating in Samegrelo Zemo Svaneti region and shall harvest more than one million m^3 of wood. Around half of million m^3 and more is timber to be cut in Kakheti and Imereti. Officially identified annual harvest volume is 178 429 m^3, but in practice license holders are producing only about 100 000 m^3 of wood[21]. The reason of difference is that the Government has issued licenses based on very rough estimation of wood stock capacity for licensed forests. These figures were corrected based on forest inventory conducted by license holders[22] which identified much less volumes of harvestable timber almost on each license area. Another obstacle is the weak operational capacity of forest entrepreneurs along with very poor condition of infrastructure, in particular forest roads, skidding trails, forestry machinery, etc. Therefore, total wood biomass accumulated after producing of 100 000 m^3 timber in the last four years is about 25 000 m^3 per one year (25%[23] of timber harvested within this period).

There are also considerable amounts of chestnut wood left in chestnut forest stands where private companies are operating. The main objective of their activity was to improve ecological conditions in these forests highly affected by chestnut blight disease and, thus they are obliged to undertake sanitary cut and remove all diseased trees. In practice companies are focused on cutting the best trees

[21] Source: Estimation by National Forestry Agency.

[22] This is an official obligation of license holders derived from their license conditions based on Government Decree #132, article 8.

[23] We estimate that only 25% of usable wood waste might be collected in forest excluding 5% of sawdust and 5-8% small brunches and foliage not possible for collection.

and leave diseased ones in the forest[24](see picture 2 and 3). This has resulted in high number of standing dead trees to be cut and removed chestnut and considerable volume of wood waste biomass including big wood trunks (see picture 4) in the forest. According to the rough expert visual estimation and verbal information from local foresters this may comprise some of 300 000- 400 000 m^3 of wood biomass. More accurate assessment of volume of dead standing trees to be cut and removed requires special inventory.

In total the existing wood waste biomass accumulated after timber harvesting operations in last 3-5 years by private companies including chestnut wood waste is estimated at ***0, 5-0, 6 million m³*** *that is made up of 400 thousand m^3 of wood waste in chestnut forests and about 100 thousand m^3 derived from harvesting operations conducted by license holders. Annual production potential of biomass waste in woods in case the license holders will continue every year harvesting of about 100 thousand cub.m to be around 25 thousand cub.m .*

Local Population

Local population of Georgia, especially in rural areas intensively consumes firewood for heating and satisfaction of their subsistence needs. Data obtained from official sources on the annual amount of fire wood is provided in the table below:

Picture : Wood waste left in forests

[24] This is confirmed several times by relevant state authorities through their inspection reports.

Table 6. Information on fire wood harvest by regions on the territory of State forest Fund managed by National Forest Agency

#	Years	Volume harvested (m^3)
Kakheti Region		
1	2010	172648
	2011	145824
	2012	87627
	2013	128732
Subtotal		***534831***
Qvemo Kartli Region		
2	2010	75371.26
	2011	70971.07
	2012	46622.2
	2013	46574
Subtotal		***239538.53***
Shida Kartli Region		
3	2010	101889
	2011	62773
	2012	41556
	2013	78888
Subtotal		***285106***
Mtskheta Mtianeti Region		
4	2010	79096
	2011	56031
	2012	43068
	2013	50371
Subtotal		***228566***
Samtskhe Javakheti Region		
5	2010	83017
	2011	86313
	2012	54214
	2013	85354
sSubtotal		***308898***
Imereti Region		
6	2010	26898
	2011	12079
	2012	11288
	2013	62908

Subtotal		***113173***
Guria Region		
7	2010	15372
	2011	10534
	2012	22460
	2013	7984
Subtotal		***56350***
Samegrelo-Zemo Svaneti Region		
8	2010	53027
	2011	30852.6
	2012	10331
	2013	24153
Subtotal		***118364***
Racha-Lechkhumi Qvemo Svaneti Region		
9	2010	34380
	2011	30570
	2012	40532
	2013	52485
Subtotal		***157968***
Total		***2 042 794***

Some of 511 000 m^3 of wood waste biomass has to be accumulated after obtaining of 2 042 794.77 m3 fire wood by local population during the years 2010-2013. Most of fire wood is harvested in Kakheti region (534 831 m^3). Annual official cut of fire wood in Georgia is around 550-600 thousand m^3 which will left about 150 Thousand of available wood waste biomass in the forest. It should be noted that official figures are based on calculation of the volume of standing tree which is allocated for harvesting. Therefore local people are paying tax for fire wood identified by law "On taxes for use of natural resources" (2004) in accordance to standing volume which is 3 GEL for 1 m^3 for hardwood species. At the same time Government Decree #46 of 2010 "On primary processing of round logs at the territory of Georgia" provides provision which requires prior transportation of fire wood from felling area to final destination logs to be sawn by 1 meter, otherwise not sawn logs to be recognized as commercial and tax to be paid is much higher (47 GEL for 1 m^3 for hardwood species)[25]. In practice such legal circumstances force local population to undertake extra wood processing works in forest which increases amount of wood waste left. Another issue for consideration (to be subject of special research) is a difference between a volume of wood calculated for standing tree as logged m^3 and the volume which people are taking home calculated based on tight volume.

[25] This is an important legal obstacle which forces private companies holding forest use licenses to leave in forest all the timber which do not have commercial value.

Another important issue that deeply worries the Georgian society since independence (1990) is an actual amount of fire wood used. There were several studies conducted by different international and national organizations[26] in different times which agree that in reality the volume of fire wood consumed every year is much higher on official figures and to be around 3 million m^3 oftight volume.

Therefore the estimated amount of wood waste from cutting by population is much higher and may amount about extra 500-600 thousand m^3.

Sawmills

According to official information provided by the Ministry of Environment and Natural Resources Protection (MENRP) there are 688 wood processing sawmills in Georgia (see table 7).

Table 7. List of officially operating sawmills in Georgia

Regions	Number of sawmills
Adjara AR	99
Guria	31
Imereti	118
Kakheti	68
Mtskheta Mtianeti	8
Racha Lechkhumi	66
Samegrelo	112
Samtskhe Javakheti	114
Qvemo Kartli	2
Shida Kartli	67
Tbilisi	3
Total	**688**

During the period of 2013 and 2014 these sawmills processed about 155 thousand m3 of round wood (see Table 8), most of which was processed in the region of Samegrelo Zemo Svaneti where 112 sawmills are operating (44 568 m3). In total, during the year 2013 and half of 2014 154 625 m3 of round wood was processed in Georgia.

We estimate the amount of wood waste in the sawmills according to FAO calculation (see table 8) to be as 34% of processed round wood volume

[26] First study was conducted by Tacis in 1994. After follow studies done by World Bank, USAID, UNDP and several Georgian NGO's (Georgia Greens Movement, Green Alternative, CENN).

Table. 8 Wood waste biomass after processing

Type f residue	% of total
Slabs, edgings and off-cuts	17
Sawdust and fines	7,5
Various losses	4
Bark	5,5
Total	**34%**

Table 9. Volume of round wood processed by sawmills from January 2013 to August 2014

Region	N	Municipality	2013	January-August 2014	Wood waste,m^3
Shida Kartli	1	Khashuri	4 230	1 056	1797
	2	Kareli	1 727	1 010	930
	3	Kaspi	12	4	6
	4	Gori	3 008	934	1340
		Total	**8 978**	**3 006**	**4073**
Mtskheta-Mtianeti	5	Tianeti	45	15	20
	6	Dusheti	-	96	32
		Total	**44.88**	**111**	**52**
Samtkhe-Javakheti	7	Borjomi	675	292	328
	8	Aspindza	2 036	191	757
	9	Adigeni	4 690	2 971	2604
	10	Akhaltsikhe	3 857	1 064	1673
		Total	**11 260**	**4 517**	**5364**
Imereti	11	Khoni	86	69	53
	12	Tkibuli	139	266	138
	13	Chiatura	1 499	356	631
	14	Sachkhere	6 242	946	2444
	15	Vani	749	278	349
	16	Bagdati	1 017	709	587
	17	Zestaphoni	63	107	58
	18	Kharagauli	64	67	44
	19	Tskaltubo	44	1	15
	20	Terjola	1 043	1 412	835
	21	Samtredia	50	22	24
	22	Kutaisi	12 942	156	4453
		Total	**23 943**	**4 392**	**9634**

Guria	23	Ozurgeti	180	210.	132
	24	Lanchkhuti	598	127	246
	25	Chokhatauri	1 867	466	793
		Total	**2 645**	**804**	**1173**
Racha-Lechkhumi Qvemo Svaneti	26	Ambrolauri	6 316	22 997	9966
	27	Oni	2 654	111	940
	28	Lentekhi	764	78	286
	29	Tsageri	451	38	166
		Total	**10 186**	**23 225**	**11360**
Samegrelo -Zemo Svaneti	30	Mestia	15 011	2 472	5944
	31	Martvili	6 344	1 349	2616
	32	Chkhorotsku	392	506	305
	33	Tsalenjikha	7 406	2 593	3400
	34	Zugdiidi	2 536	900	1168
	35	Abasha	477	313	268
	36	Khobi	257	179	148
	37	Senaki	443	553	338
	38	Poti	2 575	255	962
		Total	**35 444**	**9 123**	**15153**
Kakheti	39	Sagarejo	38	33	24
	40	Lagodekhi	90	232	110
	41	Kvareli	1 420	1 633	1038
	42	Telavi	479	419	305
	43	Akhmeta	874	410	436
		Total	**2 903**	**2 729**	**1915**
Adjara A.R.	44	Kobuleti	1 050	1 090	727
	45	Khelvachauri	1 151	1 641	949
	46	Qeda	120	146	90
	47	Shuakhevi	3 945	443	1492
	48	Khulo	776	250	349
		Total	**7 044**	**3 572**	**3609**
Tbilisi	49	Tbilisi	215	475	234
		Total	**215**	**475**	**234**
Total Georgia			**102 66**	**51 958**	**52572**

Wood waste biomass left in sawmills during the 1,5 year period mentioned in table 9 to be around **53 Thousand m^3** presented by Slabs, edgings and off-cuts, sawdust, etc. which is equal to 34% of total round wood volume processed. There are no official data on the amount of biomass accumulated during the last years at sawmills territories. We may base on the figures identified by study "Potential of woody biomass in energy sector and their efficient use" in 2010 which estimates this amount accumulated in previous years around 228 thousand m^3. There are only very limited number of sawmills in Georgia which are based on modern non waste technology. Further increase of number of modern sawmills is highly depend on development of forest sector with clear legislation and close to best European standards forestry operations which from today point of view still under the question mark. Therefore, if assume that existing sawmills continue their work according to volumes provided in table 8 it may leave every year about 30-40 thousand m^3 of available wood waste.

High priority sub-regions (districts) can be selected from the table based on the amount of waste biomass in the last column. Though, additional field investigation is required to identify the conditions of such old accumulations and their further usability.

Identification and characterization of potential new sources of woody biomass not in use now but potentially useful for energy

With regards to potential new sources which may accumulate considerable amount of woody biomass following important silvicultural measures need to be focused on: (i) thinning operations, and (ii) support of natural regeneration.

Early & Mid-term Tending and Thinning

Early tending of young-growth stands or forested plots is intended to prevent damage, promote and select target species and trees and to exclude dominating undesired trees, bushes or shrubs (e.g. *vines*, *Rubus, rhododendron, laurocerasus etc.*) that might cause undesired promotion of pests or diseases (e.g. fungi) or otherwise affect future regeneration of the target population. It is supposed to facilitate an unrestricted development of the target species or individuals.

Mid-term tending is oriented at retaining damaged or sick individuals for reasons of forest protection and to regulate the general **species mixture and stand structure** (multi-storeyed) towards the target. Potential elite trees are identified and promoted, as well as supporting or admixture individuals of promising properties.

Frequently, about half of utilizable timber volume from particular forest stand is extracted during different stages of these forestry operations.

In Soviet period and sometime after independence production of about 300 thousand m^3 of timber through thinning operations were planned each year, though radical decrease of state funding after independence completely "removed" this activity from usual forestry practices in Georgia which is not recovered until now. Only very recently, Tbilisi Municipality, which is responsible for the management of surrounding forests, initiated such activity and conducted thinning operations in high density pine stands.

Therefore, most of Georgia forests urgently require proper planning and implementation of thinning operations to ensure their biological and ecological stability. Taking in account that at least 20 years no thinning operations were arranged in Georgia forests, we can assume the annual cut to be about 500 thousand m^3which corresponds

to estimated current ecological condition of forests and the necessity of corrective actions. Total amount of timber of which maximum 50% might be commercially utilizable wood, rest amount (250 000 m^3) might be considered as potential wood waste biomass.

Picture 5. Early tending need for young forest stands in Chkhorotsku forests

Measures to support natural regeneration

This is an important silvicultural measure which aims to ensure natural regeneration of target tree species through removal of undesired trees, bushes or shrubs which completely cover soil under the stand canopy and disturb germination of seeds and successful growth of main tree species. In Georgia forests, significant problem for natural regeneration is high distribution of *Rhododendron* and *Laurocerasus* bushes mainly in broadleaved forest stands, which comprise more than 80% of forest cover, with more favorable climate conditions for their growing. By rough estimation at each hectare about 10-15 m^3 of *rhododendro*n and *Laurocerasus* wood biomass is accumulated[27]. **Therefore, cleaning of only one thousand hectare of forest may produce 15 thousand m^3 very high energy value[28] of alternative woody biomass**. Currently in Georgia Forestry Agency of Ajara Autonomous Republic is providing this alternative wood energy to satisfy demand of local population[29].

Picture 6. Rhododendron bushes

Fir Cones

About 900 tons of *Abies nordmanniana* cones are harvested every year by official license holders in Georgia for further processing and exporting to Europe and UK high quality seeds used for growing Christmas trees. The main harvesting locations are Ambrolauri (Racha Lechkhumi Qvemo Svaneti Region), Borjomi (Samtskhe-Javakheti) and Beshumi (Ajara AR) forests. After processing of cones (drying and removal of seeds) which gives in average 10% of

[27]Figures are based on result of forest inventory materials for Tsalenjikha forests conducted in 2008.

[28] Rhododendron wood is supposed to have the highest calorific value of any woods.

[29] Information provided by NFA of Ajara AR.

seeds all the rest is considered as waste. According information from license holders this biomass has a good energy potential and some households, directly involved in cone harvesting and processing activities are using them for heating and cooking. According evaluation by State Forestry Department in 1996 yield potential of fir stands in Georgia is amounted around 400 thousand tons per year. This may become a possible new energy source for the local population surrounding fir forest stands while they visit forest for collection of fruits and berries

Conclusions

Based on estimations in section 3 and 4 the total potential amount of wood waste biomass distributed by sources of origin is provided in table 9.

In order to arrive at energy content of residual wood biomass, we have used the following assumptions:

Moisture content for the wood residues accumulated in forests over several years 20%, net calorific value of these residues 14.7 MJ/kg - Moisture content of annually generated residues 40%, net heat value of these residues 9.8MJ/kg

Table 10. Total wood waste and alternative wood biomass energy potential by source

Source of origin	Accumulated m^3	Annual potential, m^3	Total m^3	Energy value accumulated **14.7 MJ/kg** [30]	Energy value Annual potential 9.8 MJ/kg
Timber harvesting					
License holders	500 000	25 000	525 000	4.4 PJ	0.2 PJ
Local Population	511 000	150 000	661 000	5.2 PJ	1.1 PJ
Illegal cut	1 875 000	625 000	2 500 000	19.3 PJ	4.8PJ
Total	**2 886 000**	**800 000**	**3 686 000**	**28.9 PJ**	**6.1 PJ**
Primary wood processing					
Sawmills	227 000	36 000	263 000	**2.4** PJ	**0.3** PJ
Early & Mid-term Tending and Thinning	-	250 000	250 000		**1.8** PJ
Measures to support natural regeneration[31]	-	75 000	75 000		**0.5** PJ
Total	**3 113 000**	**1 161 000**	**4 274 000**		**2.6** PJ

[30] http://www.aebiom.org/IMG/pdf/WOOD_FUELS_HANDBOOK_BTC_EN.pdf

[31] It is assumed that 5000 hectares are operated annually.

As it is shown in table 10 the potential annual production of wood waste biomass in Georgia forests may achieve 1 161 000 m^3annually of which 325 000 m^3 to be derived from alternative sources of woody biomass. **Total amount of already accumulated woody biomass is estimated at 3 113 000 m^3.** Estimation of wood waste volume related to illegal cut is based on following approach: annual harvest volume is about 2,5 million m^3, as it defined by USAID studies of 2009 and HPEP household survey of 2014. This amount may accumulate annually 625 000 m^3 and during last five years (physical conditions of hardwood species under the forest canopy can preserve for five years maximum, coniferous wood for two years) 3 125 000 m^3. About 60% of this amount are hardwood species, which will comprise wood waste volume accumulated after illegal cut during last five years at 1 875 000 m^3.

3.6. Priority regions and locations with higher concentration of wood biomass

According to statistical information analyzed it is suggested to focus on following regions, where potential of wood waste and alternative wood biomass seems higher: **Samegrelo Zemo Svaneti, Kakheti and Imereti.** Selection of these regions is based on the following criteria:

- ✓ Volume of timber harvested in last 3-5 years;
- ✓ Annual wood harvesting volume for industrial purposes and for fire wood;
- ✓ Number of sawmills operating in regions;
- ✓ Considerable areas covered by high density young forest stands which needs early and midterm tending and thinning;
- ✓ Urgent need of sanitary cut in chestnut forest stands;
- ✓ Significant areas of forest stand which require measures against high distribution of *Rhododendron and laurocerasus* species.

Volume of timber harvested in last 3-5 years

According to existing studies reviewed (Cf. table 1) in section 2, as well according to current official information provided by MEPNR Samegrelo Zemo Svaneti is the region where most of industrial timber is harvested by license holders (see table 5).

Annual wood harvesting volume for industrial purposes and for fire wood

Kakheti region is leading (see table 6) by consumption of fire wood during the years 2010-2013.

Number of sawmills operating in regions

Most of sawmills are located in Imereti (118), Samtskhe Javakheti (114) and Samegrelo Zemo Svaneti Regions (table 7) of which more intensively sawmills are operating in Samegrelo Zemo Svaneti processing around 45 thousand m^3 of round wood for the 1,5 year period (table 8).

Considerable areas covered by high density young forest stands which needs early and midterm tending and thinning

In past (Soviet period) forests of Samegrelo zemo Svaneti region were more intensively used for commercial cut. After 30-40 year forests at these felling areas are presented by high density young stands in which there is a need for immediate tending operations.

Urgent need of sanitary cut in chestnut forest stands

It is quite obvious that there is an urgent need to remove all wood waste and undertake sanitary cut in Chestnut forests of several municipalities in Imereti region (Zestaphoni, Kharagauli, Chiatura, Tkibuli).

Significant areas of forest stands which require measures against high distribution of Rhododendron species

All the forests, where broadleaved forest stands are predominant, problem of natural regeneration due to high distribution of undesired trees, bushes or shrubs, in particular *Rhododendron* species, is obvious. Because of about 80% of Georgia forests are presented by broadleaved species it is difficult to prioritize one of the region.

3.7. Existing legal background in the field of biomass waste use and needs for change

According to UNDP study "Biomass fuel production and utilization legal review" reviewed in section 2 there are many issues which require legal amendments or changes in existing Georgian legislation. We would attempt to go through this case to describe the current legal environment for the each potential source of wood biomass waste in Georgia.

Wood waste biomass accumulated after timber harvesting operations conducted by forest use license holders

The existing legal setup related to timber harvesting including system for identification fees and all the range of operations is quite complicated and requires special legal study. There are many obstacles within this system which cause difficulties for both – state forestry authorities and forestry entrepreneurs. It is not possible to make a comprehensive assessment within this short assignment. We will just try to identify key points related to how to obtain legally the wood waste biomass.

Whole tree (including small branches) cut by license holders belongs to them since they pay special fee identified by article 5, clause 2 of the Law on Taxes for use of Natural Resources (2004). After completion of felling operations license owners are obliged to clean up the felling area from wood residues and brunches according to the requirements identified in article 13 of the Government Decree #242 On the Rules of Forest Use. In case if license holder did not fulfill legal obligations and left wood residues and waste in the forest [32], National Forest Agency (NFA) is empowered (GD 242, article 10, clause 9) to allocate these resources to local population based on payment established by article 5, clause 2 Law on Taxes for use of natural resources. Payment for one cubic meter of wood is 3 GEL for species like beech and hornbeam.

[32]Subject for special penalties identified by relevant legislation.

Therefore, NFA may issue a permit for collecting the wood biomass at the license holders' areas for local population, who will apply for fire wood. ***There is no legal prescription how to act in case of private legal body application for the same issue.***

Wood biomass accumulated after timber harvesting operations conducted by local population

NFA is responsible for permission to collect wood biomass accumulated after local population conducted harvesting operations. ***How to allow the private companies to collect wood biomass is not defined by existing legislation.***

Wood biomass accumulated at sawmills-Requires a special agreement with sawmill owners since wood waste products (Slabs, edgings and off-cuts, Sawdust and fines, etc.) belong to them.

Wood biomass accumulated after Early & Mid-term Tending and Thinning-Planning, design and implementation of tending and thinning is completely under the responsibility of NFA who should lead and supervise this operations. If funding is available, NFA may involve private contractors through relevant agreement. The payment for wood shall be done according to taxes identified by Law on Taxes for use of natural resources based on their categorization by wood quality.

Wood biomass accumulated after Measures to support the natural regeneration-The same as above, except of payment due to ***Law on Taxes for use of natural resources does not regulate payment for the wood waste biomass derived from such forestry activities.***

It is quite evident that all the legal mechanisms which may ensure correct implementation and use of wood waste and alternative woody biomass are under the responsibility of the Ministry of Environment and Natural Resources Protection, which is the leading state agency in the forest sector of Georgia as well as National Forestry Agency, in charge of management of main part of national forests. According to National Forest Concept, the Ministry is responsible for development and implementation of fire wood supply program for rural population which may serve as a good basis for the adoption of proper legal instruments for the use of wood waste in Georgia.

References

[1] National forest concept for Georgia, 2014. Ministry of Environment and Natural Resources protection

[2] “Pre-Feasibility Study on Producing High Efficiency Stoves, Fuel Pellets and Briquettes in Georgia, and Related Environmental, Social and Economic Benefits”, UNDP 2010.

[3] Potential of woody biomass in energy sector and their efficient use, “Mountain 2002”, 2010

[4] Biomass fuel production and utilization legal review, Tamar Dugashvili, 2014.

[5] Recommendations to ensure efficient supply of population by energy sources, CENN, 2014.

[6] GIZ study on fire wood concept in Georgia , 2012

[7] Cadaster of Biomass Energy Potential of Georgia, Georgian Association of Energy Engineers, Tbilisi 2013, Georgia.

[8]Energy conservation in the mechanical forest industries, FAO, 1990

Recommendations and future plans

The resources of agricultural and forestry residue are significant and its using as alternative energy source can contribute to improvement of economic situation of local population and will have positive impact on environmental protection.

According to the study, the highest potential energy from biomass waste is coming from the forestry. It amounts to 40PJ or more than 11 Terawatt hours (TWh) which exceeds current annual electric energy consumption of Georgia. Corn straw seems to be the second largest potential energy sources with almost 22PJ of annual potential. However this conclusion needs to be treated with more care and needs to be confirmed for the actual sown areas, per area yield of the residue and its current alternative use. The highest potential unused residue in perennial crops may be from vineyard pruning (2 PJ/a) this potential needs to be studied in more detail for current practice in the regions and might be also complemented by grape pressings from the wineries.

In order to have a more realistic, detailed and comprehensive view on the biomass resources in Georgia further studies should be carried out in the three main areas of research as follows:

Agricultural Residue from Perennial Crops in Georgia

Accurate estimate of available crop residues for bioenergy purpose is important for the sustainability of biomass supply. As a next step of comprehensive assessment of the current amount of available crop residues, operational GIS-based approach is proposed (Geographic Information System). The five regions with highest potential amount of biomass are Samegrelo-Zemo Svaneti, Guria, Imereti, Kakheti and Shida Kartli. The main crops for each region must be selected according to this assessment's results: hazelnut should be the object of study in Samegrelo-Zemo Svaneti and Guria; bay leaf in Samegrelo-Zemo Svaneti, Guria; fruit orchards and vine for Shida kartli and vineyards in Kakheti and Imereti. Next step should be the field evaluation of data collected by GIS.

ACTION PLAN

Main Targets

Objective	Target	Outputs
1. Definition of the available biomass in Georgia through GIS (Geographic Information System) **2. Definition of the available biomass in Georgia through field visits** **3. Promotion of agricultural residues' using as alternative energy source in Georgia and support to improvement of crop-residue using in Georgia.**	**Conduct the comprehensive assessment of the current amount of available crop residues.**	- **Online map of available biomass in Georgia by selected regions and plants** - **Comprehensive assessment on available biomass in Georgia** - **Report**

2. OBJECTIVE 1: Definition of the available biomass in Georgia through GIS (Geographic Information System)

TARGET: Defined amount of available biomass in Georgia in 5 regions 4 agricultural sectors for future study.

Target Date - October, 2014 – TBD

Proposed Action	Milestone Tasks	Success Indicator	Progress
- Conduct study on area of main crops by regions with GIS - Creation of data base of area of main crops by regions	- Select the service provider - Elaborate the action plan with service provider - Collect information - Analyze collected information - Creation of the data base for future study	Bases of comparison of data from theoretical assessment and defined amount of available biomass from GIS	- GIS defined amount of available biomass in Georgia in 5 regions 4 agricultural sectors for future study - Created data base of area of main crops by regions

OBJECTIVE 2:
Definition of the available biomass in Georgia through field visits

TARGET: Ddefined amount of available biomass in Georgia.
Target Date - January, 2015 – August, 2015

Proposed Action	Milestone Tasks	Success Indicator	Progress
- Development of data base for main producers/ processing plants by crop/region - Field visits in regions. Purpose: to define exact area under orchards, production, diseases/pest, yield losses and reason of loses, availability of crop-residue for collection - Mapping of data on available biomass according to collected information - Assessment of availability and rough cost estimate of colleting the bioass	- Collect information on main producers/ processing plants by crop/region - Development of survey for data collecting - Arrangement of visits in regions** - Meetings with the regional information-consulting centers at MOA - Meetings with crop producers: a) farmers and b) businessman - Meetings with processing plants - Meeting with locally presented international organizations - Field visits, data collection - Analyze collected information - Compare the data collected with GIS - Creation of the data base - Identify the service provider for creation of online map and Creation of online map	Number of users of the created online map Improved reliability of data on available biomass in Georgia	Online map of available biomass in Georgia by selected regions and plants

OBJECTIVE 3: Promotion of agricultural residues' using as alternative energy source in Georgia and support to improvement of crop-residue using in Georgia.

TARGET: Agro residue using culture as alternative energy source will be introduced in Georgia.

Target Date - August, 2015 – December, 2015

Proposed Action	Milestone Tasks	Success Indicator	Progress
- Prepare recommendation for improvement of crop-residue using - Development of comprehensive assessment - Organize the workshop on agricultural residues' using as alternative energy source in Georgia - Arrange demonstration plots to introduce agricultural residues' collection methodology - Prepare and publish brochures on agricultural residues' collection methodology - Prepare the promotional video (3-5-10 minutes) on Agro residue using culture as alternative energy source and show through local TVs	- Analyze data from GIS and field visits - Prepare recommendations - Prepare the workshop - Demonstrate the project's results - available biomass in Georgia through created online map - Select one plot in each region (5) - Define trial crop for each selected plot - Development of agricultural residues' collection methodology - Introduce methodology on agricultural residues' collection - Publish/distribution of methodology on agricultural residues' collection - Prepare the promotional video - Show the video in local TVs - Monitoring of the plots	Number of watchers of video by regions Number of household introduced the technology	Recommendation for improvement of crop-residue using Comprehensive assessment on available agricultural residues in Georgia The workshop on agricultural residues' using as alternative energy source in Georgia Brochures Promotional video 5 demonstration plots

**Field visits' scheme by regions, districts and crops.

Region/Crop	BAY LEAF	HAZELNUT	VINEYARDS	FRUIT ORCHARDS
Samegrelo-Zemo Svaneti	Two weeks	Two weeks		
Abasha district	July-August, 2015			
Zugdidi district				
Martvili district				
Senaki district				
Chkhorotsku district				
Tsalenjikha district				
Khobi district				
Shida Kartli			One week	One week
Gori district			April, 2015	
Kaspi district				
Kareli district				
Khashuri district				
Imereti			Two weeks	
Bagdati district			May-June, 2015	
Vani district				
Zestafoni district				
Terjola district				
Guria	One week	One week		
Lanchkhuti district	July-August, 2015			
Ozurgeti district				
Chokhatauri district				
Kakheti			Two weeks	
Akhmeta district			September, 2015	
Gurjaani district				
Dedoplistskaro district				
Telavi district				
Sagarejo district				
Signagi district				
Kvareli district				

Annual Crop Residual Biomass of Georgia

1. Compile the data base regarding to crop development should be organized due to crop type through sown area and yield of production by regions as detail as possible;
2. GIS system development and inclusion would be helpful and one of the important measure of data collection and analysis.
3. Should be identified most common crop types by varieties, because the different kind of varieties are featured in different individual characters e.g. the corn varieties of Western Georgia quite differs from Eastern Georgia varieties; e.g. in Estern Georgia most common corn vatieties are “Kartuli Krugi” and occupies about 20 thsnd ha which grows up to 3.2 m. in height, another is “ Kaja Kviteli’ grows up to 2.2 m. In the Western Georgia the most common vatieties are “ Aajmetis Tetri” and “Abashuri Kviteli’ both are popular too much and growing up more than 3.8 m. in height.
4. Define the RPR ratios of residue yield and energy value by crops;
5. Identify the abandoned land territories for biomass development and inclusion for further follow up planning;
6. Conduct the workshops with local experts and experienced farmers
7. Field visits at least at regional level;
8. Monitor the field activities at least in three times in each municipality and choose field plots in random selection : at the beginning, during the vegetation and harvesting time;
9. Would be better collection of alternative statistical figures via triangulation using official / informal sources; Can be done through GIS

Based on data analysis the most favorite regions regarding to theoretical residue potential and energy value might be considered Kakheti, Imereti, Samegrelo-Zemo Svaneti, Shida Kartli and Kvemo Kartli. The Mtskheta-Tianeti, Samtskhe-Javakheti and the rest of regions are considered as low potential regions in term of residual biomass but with hopeful perspectives.The corn is most valuable within existing crops as for energy utilization as f the best fodder resource particularly in Western Geiogia.

Main Activities broken down through specific activities

Main Activities	Specific Ativities
Informational meetings with GoG National/ Regional representatives, GeoStat etc.	The meeting should collect several GoG representatives from MoA, MoE, GeoStat and interested parties to inform on purposes and planning activities
Workshop including experts, farmers and stakeholders	The workshop should collect experts, farmers and stakeholders etc, to discuss GIS system introduction, specifics of residual biomass features e.g. ratios, crop variety distribution, alternative uses of biomass, existing local and foreign residue processing technologies etc.
Field visits and identification of targeted area for monitoring	Field visits should conducted to regional offices and MoA information centers to introduce planning activities and discuss availability of their contribution. Identification the methodology of data collection, monitoring mechanisms and targeted places for observation. There are 10 regions and 61 'de municipalies facrto' (additional 2 AR and 6 municipalities are "de iure') in Georgia and meeting could be held in each regional offices.
Field monitoring visits and reporting	Development of monitoring plan, then field monitoring visits to MoA information center and collection of information ongoing processes. Identification the challenges during the observation.
Collection data and analysis	Finalize data collection, including GIS figures, compare to the rest of figures, Identify gaps if any, conduct research / survey on alternative use of residues.
Final Report	Develop finale report including, introduction, methodology, main findings, challenges, recommendations, conclusions and follow up activities.

Final workshop	Conduct final / summarized workshop involving all stakeholders, especially GoG and commercial parties. Identify successes, lessons learnt, potential resources and follow up planning.

Action Plan

Activities	**IV quarter, 2014**	**I quarter, 2015**	**II quarter, 2015**	**III quarter, 2015**	**IV quarter, 2015**
Informational meetings with GoG National/ Regional representatives, GeoStat etc.	X				
Workshop including experts, farmers and stakeholders	X	X			
Field visits and identification of targeted area for monitoring		X	X		
Monitoring visits and reporting		X	X	X	
Collection data and analysis				X	X
Final report					X
Final workshop and planning					X

Wood waste and Alternative Woody Biomass

There is a considerable amount of wood waste accumulated in Georgia forests as well as alternative woody biomass. Based on very rough estimation more than 1, 7million m^3 of wood waste is already spread out in the regions of Georgia. Every year after different forestry operations (timber and firewood harvesting, forest tending, primary wood processing, support of natural regeneration etc.)about 700(+500 from illegal cut) thousand m^3 wood wastes can be expected.

With the support of Georgian Government and financial contribution of international donor organizations development of complex measures on use of wood waste with their further processing into highly efficient fuel material like wood pellets and briquettes, seems to be a high priority for the development of forest sector. Results of the practical implementation of these measures might be as follows:

- ✓ Improve forest ecosystems' health and vitality through removal of existing wood waste;
- ✓ Improve forest biodiversity through specific "close to nature" forestry measures aiming to ensure species, age and structural diversity and successful natural regeneration;
- ✓ Supply of Georgia rural population with efficient, affordable fuel material;
- ✓ Reduce the pressure on national forests due to availability of alternative energy sources;
- ✓ Establishment of alternative employment opportunities for rural population.

Wood waste and alternative woody biomass feasibility study in Georgia

Objective

Primary objective of the assignment is: (i) selection of potential pilot region for development of use of wood waste and/or alternative woody biomass, (ii) undertake detailed estimation in selected region of the volume of wood waste and alternative woody biomass that is available for alternative energy production on a long-term sustainable basis, and (iii) prepare a business plan for its supply accounting explicitly for a range of environmental, operational, and economic assumptions.

Scope of Work

Phase I – Selection of priority sub-regions and sites for field visits

Review the existing information on wood waste and alternative woody biomass distribution in Georgia.

Define priority sub-regions and undertake relevant field observations; prioritization to be based on following criteria:

- Volume of timber harvested in last 3-5 years;
- Annual wood harvesting volume for industrial purposes and for fire wood;
- Number of sawmills operating and their actual production and potential capacity;
- Considerable areas covered by high density young forest stands which needs early and midterm tending and thinning;
- Urgent need of sanitary cut due to high distribution of diseased and deadwood trees;
- zSpecies composition preferably with prevalence of broadleaved species;
- Significant areas of forest stand which require measures against high distribution of invasive bushes like *Rhododendron and Laurocerasus*;
- Availability of forest road infrastructure and their condition.

Analyze the obtained information and justify pilot sites for further research.

Phase II – Estimation of wood waste and alternative woody biomass in selected pilot sub-regions

- ✓ Identification of basic wood waste accumulation areas. At each area conduct: a) estimation volume of timber harvest residuals left on-site, and b) relevant biological and physical characteristics of those timber harvest residues such as species, typical size, mixture of inorganic materials, density, moisture content, and distribution across logging areas;
- ✓ Projections of volumes of biomass that could result from a) commercial timber harvesting operations; b) fire wood harvesting; c) early & mid-term and thinning operations; d) sanitary cuts; e) measures aimed to support natural regeneration and f) other origins, if any;
- ✓ Estimation of volumes of biomass accumulated at sawmills operating in the region and projection of their annual capacity;
- ✓ Stratification of relevant wood waste and alternative woody biomass component supply assessment by: a) existing forest road infrastructure and their conditions, maintenance or renovation needs; b) distance to main road; c) site conditions (slope, etc.); d) collection and removal methods and technologies required including operational constraints and consideration of seasonality;
- ✓ Mapping of the territory;
- ✓ Estimation of total volume of wood waste and alternative woody biomass that is available for alternative energy production on a long-term sustainable basis;
- ✓ Rough cost estimate of collecting the wood biomass.

Phase III – Wood waste and alternative woody biomass supply business plan

Preparation of standard business plan including an analysis and estimation of the operationally feasible volume, cost, and quality of removed biomass under a range of reasonable scenarios. The scenarios must be based on a reasonable range of at least the following considerations:

- Ecological availability;
- Biomass physical characteristics;
- Site conditions;
- Collection and removal methods and technologies and road system characteristics and management, including operational constraints and consideration of seasonality;
- Operational relationship of biomass collection and removal to existing logging operations, if any (collection by logging operator; collection by another party at same time as logging; collection by another party following logging).

Potential processing technology (pellets, briquettes, direct use as fuel)

Risk assessment and mitigation measures.

- Employment opportunity for local population.

Annexes

Annex I. List of wood harvest license holders,

Ministry of Environment					
August 4 2006					
#	Region	Area (ha)	Annual harvest plan (m^3)	License holders	License number and validity
1	Martvili forest division – Kurdzu and Taleri sections	4 920	208 000	Ltd. Georgian forest	00174 20 years
May 1 2007					
Ministry of Economy and Sustainable development					

October 7 2008

№	**Region**	**Area (ha)**	**Annual harvest plan (m^3)**	**Winning companies**	**License number and validity**	**Transfer**
1	Samtskhe-Javakheti region, Akhalcikhe forestry division. section #65	203	472	Ltd- Kusha 2011 ` Grant on lease to ltd Sako from 14.11.2012 to 15.11.2013	1000028 Till 27.10.28	Part of the 100072 license was transferred by I.E Vefxvia ShubitidzeOrder number: Z.1-1/1590 30.09.10v. 0000021 license was fully transferred by I.E Zaza Kavelidze 13/425 20.09.12
2	Samtskhe-Javakheti region, Akhalcikhe forestry division sections #64; 68; 69.	406	300	Ltd. Fatati:	100073 20 years	Part of the 100009 license Was transferred by I.E Vefxvia Shubitidze 1-1/1361 11.08.10w.

3	Mtskheta –Mtianeti region, Tianeti forestry division, Tianeti sections 29,31,37	485	521 (Beech)	Ltd. M. House +. Registration number: 206319465	1000044 from .03.14 till 16.10.28	Part of the 1000043 license was transferred to Ltd. Rash 142 13.03.14 100010 license amendment #88 21.02.14
4	Mtskheta –Mtianeti region, Tianeti forestry division, Tianeti sections 34,35,36	366	500 (Beech)	Ltd. Rash	1000045 from -13.03.14 till 16.10.28-	Part of the 1000043 license was transferred by Ltd. ,M. House 141 13.03.14 100010 license amendment #88 21.02.14

October 8 2008

№	**Region**	**Area (ha)**	**Annual harvest plan (m^3)**	**Winning companies**	**License number and validity**	**Transfer**
1	Guria region, Chokhatauri forestry division sections Zota –(24,36-40,42-83 Zemosurebi (22-26,34-39,49-51 .)	Zota (5382 ha); Zemos urebi (1831 ha)	11 022	Ltd. GURIA JF	100071 20 years	100007 license amendment order.1-1/2220 15.10.08y. 1-1/2726 27.11.09y. 100046 license amendment 1-1/1265 28.07.10

September 22 2009

№	**Region**	**Area (ha)**	**The type and amount of extractable resources (m^3)**	**Winning companies, Registration number**	**license number**	**Registration, order number, license validity**
2	Samegrelo-Zemo Svaneti, khaishi forestry division, Chuberi sections (47,48,52,54)	369	Beech _ 765 Fir_ 13410	Ltd. LKV COMPANY	100003 6 (100023 License was fully transpir ed by I.E. Irakli Miqava	number #291 09.09.13 #1-1/2450 from 28,10,09 till 29.10.19
3	Shida Qaqrli region, Khashuri forestry division (1-5,7-30,33-42)	5681	Spruce _ 5944 Fir _ 1962 Beech _ 7074 Pine-tree _ 142 Spruce _ 5140 Fir _ 1781 Beech _ 4487	I.E. Raguli Tabatadze	100026	29.10.09 #1-1/2452 28,10,09 10yr

4	Imereti region, Sachkhere forestry division, Ckhami sectios (6,7,8,13,15,16,22)	963	Beech _ 13970 Beech_ 615	Ltd. International Timber Producing Company	100025	03.11.09 #1-1/2453 28,10,09 10 y.
5	Samtskhe-Javakheti region, Adigeni forestry division Utyisubani sections (10-13,15-18,21-26,28,29)	2571	Fir _ 5067	ltd TAO	100013	19.10.09 #1-1/2308 12,10,09 10 y
6	Samegrelo-Zemo Svaneti region, khaishi forestry division, Chuberi sections (6,7,8,17,23,24)	723	Beech _ 790 Fir, Spruce _ 2070	I.E. Gia Davitiani	100017	05.11.09 #1-1/2351 20,10,09 10 y
7	Mtskheta-Mtianeti region, Tianeti forestry division, Sioni sections (39,42-48)	790	Beech _ 2570 Beech _ 3149 Hornbeam _ 117	Vakhtang Betlemidze	100027	04.11.09 #1-1/2504 02,11,09 10 y.

8	Mtskheta-Mtianeti region Dusheti forestry division , Magaroskari sections (1-5,13-16.)	1575	Beech _ 5700	Vakhtang Betlemidze	100038	17.11.09 1-1/2558 13.11.09 10 y
9	Racha-Lechkhumi region. Ambrolauri forestry division, Gviara sections (16,1920)	413	Beech_ 11 180 Fir, Spruce _ 22500	Ltd. IR.Tour	100064 (100057 duplicate license)	05.01.10 1-1/2917 29.12.09 10 y
10	Racha-Lechkhumi region, Ambrolauri forestry division Uravi sections (46.47.48.50)	630	Beech_ 9950 Fir _ 11 660	Ltd. Rioni Wood	100070 (100048 license was fully transferred by Ltd. Aisbergi	13.07.10 1-1/879 01.06.10 1-1/1173 13.07.10 10 y

October 8 2009

№	**Region**	**Area (ha)**	**The type and amount of extractable resources m³**	**winning companies, registration number**	**license number**	**Registration, order number, license validity**
1	Samegrelo-Zemo-svanetiregion, Khaishi forestry division, Ormeleti sections (5,13-16)	570	Beech _ 180 Fir _ 2345	Jeiran Cindeliani	100044 (100032 license was fully transferred by Jeiran Cindeliani)	24.11.09 #1-1/2509 02,11,09 5 y
2	Samegrelo-Zemo-svaneti, Khaishi forestry division, Ormeleti (48,49-50)	344	Fir_ 600	LTD. X.D.K.iv	100016	27.10.09 #1-1/2372 20,10,09 5 y
3	Samegrelo-Zemo-svaneti Khaishi forestry division, Ormeleti(11,12,31,32)	480	Beech _ 66 Fir_ 4100	Ltd. X.D.K.iv	100020	27.10.09 #1-1/2371 20,10,09 5 y

4	Samegrelo-Zemo-svaneti Khaishi forestry division, Chuberi(84,85,87,92-94)	807	Beech_ 556 Fir_ 1625	Ltd. X.D.K.iv	100036	09.11.09 #1-1/2529 05.11.09 5 y
5	Samegrelo-Zemo-svaneti Khaishi forestry division, Chuberi(67-72)	686	Beech _ 380 Fir_ 1855	Ltd TAVRARI	100031	04.11.09 #1-1/2514 02,11,09 5 y
6	Samegrelo-Zemo-svaneti Khaishi forestry division, Chuberi(78-80,86,88)	819	Beech _ 100 Fir _ 891	I.E. Silibistro Jachvliani	100014	23.10.09 #1-1/2393 23,10,09 5 y
7	Samegrelo-Zemo-svaneti Khaishi forestry division, Chuberi(95,97,100)	502	Beech_ 76 Fir _ 1255	Ltd. Vibliani	100035	05.11.09 #1-1/2511 02,11,09 5 y

8	Samegrelo-Zemo-svaneti Khaishi forestry division Khaishi (1,2,3,13,14)	524	Beech _ 1070 Fir, Spruce _ 7836	I.E. Nugzar Chkadua	1000018 (100045 license amendment) (100034 license was fully transferred by Nugzar Chkadua	13/173 15.03.12 26.11.09 #1-1/2703 20,11,09 02.11.14
9	Samegrelo-Zemo-svaneti Khaishi forestry division Khaishi (15,16,27,28,29,30)	717	Fir, Spruce _ 1927	Avtandil Kvanchiani	100030	04.11.09 #1-1/2513 02,11,09 5 y
10	Samegrelo-Zemo-svanetiKhaishi forestry division. Jorkvala (32-44,54,55)	2773	Beech 440 Fir, Spruce _ 2771	I.E. Kakhaber Chanturia	100043 (100024 license was fully transferred by Ltd. Bubu and Company	24.11.09 #1-1/2705 20.11.09 5 y

11	Samegrelo-Zemo-svaneti Mestia forestry division, Lakhamuli (49,48,50,51,52,53)	1154	Beech _ 320 Fir_ 2860	Ltd. NEW CONSTRACTION ~	1000035 Ltd, Inguri 2006 100029 amendment in the license.	01.07.13 126 01.07.13 26.11.09 1/1/2512 02.11.09 5 y
12	Samegrelo-Zemo-svaneti Khaishi forestry division, Chuberi (75,78,79,80,83)	643	Beech _ 133 Fir, Spruce _ 529	Ltd. Ushba-2004	100022	30.10.09 #1-1/2449 28,10,09 5 y
13	Samegrelo-Zemo-svaneti Mestia forestry division Jorkvali (3,4,5)	444	Fir, Spruce _ 1285	Ltd. Khaishi 2007	100062	100021 amendment in the license 1-1/150 28.01.10 #1-1/2448 28,10,09 5 y
14	Samegrelo-Zemo-svaneti Khaishi forestry division Ormeleti(51-53,66,67,89)	738	Beech _ 430 Fir, Spruce _ 4253	Ltd. GTA Company	100037	09.11.09 1-1/2528 05.11.09 5 y

15	Samegrelo-Zemo-svaneti Khaishi forestry division Ormeleti(65,88,100-109)	1520	Beech _ 2680 Fir, Spruce _ 9752	Ltd. GTA Company	100012	20.11.09 1-1/2697 20.11.09 5 y
16	Samegrelo-Zemo-svaneti Khaishi forestry division khaishi(4.5.6.7.8)	599	Beech _ 472 Fir, Spruce _ 6440	Ltd. GTA company	100015	20.11.09 1-1/2696 20.11.09 5 y
17	Samegrelo-Zemo-svaneti Khaishi forestry division Khaishi(69.70.83.84.97.98)	1064	Beech _ 2450 Fir, Spruce _ 7432	Ltd. GTA company	100042	20.11.09 1-1/2698 20.11.09 5 y
18	Samegrelo-Zemo-svaneti Khaishi forestry division Ormeleti(6.17.36-38)	545	Fir _ 2084	I.E Nunu Chkadua~	100059 (100052part of the license was transferred to I.E Dato Cindeliani	13.01.10 1-1/2728 27.11.09 1-1/14 11.01.10 5 y

19	Samegrelo-Zemo-svaneti Khaishi forestry division Ormeleti(35)	138	Fir _ 1287	I.E. Dato Cindeliani	100060 (100052 100052 part of the license was transferred by Nunu Chkadua	13.01.10 1-1/2728 27.11.09 1-1/15 11.01.10 5 y
20	Samegrelo-Zemo-svaneti Mestia forestry division, Lakhamula (17.20.32)	676	Fir, Spruce _ 4268	Ltd. Grigali	100077 (100053 part of the license was transferred to Ltd. INGURI	18.08.10 1-1/1386 16.08.10 5 y
21	Samegrelo-Zemo-svaneti Mestia forestry division, Lakhamula (31.39.41.42.45)	960	Beech _ 256 Fir, Spruce _ 2237	Ltd. Inguri	100074 (100053 part of the license was transferred by Ltd. GRIGALI	18.08.10 1-1/1387 16.08.10 5 y
22	Samegrelo-Zemo-svaneti Mestia forestry division, Jorkvala(1.2.13.14.25)	773	Beech _ 516 Fir, Spruce _ 7445	Ltd. Bubu and Company	100061 (100039 license amendment)	01.02.10 1-1/2688 19.11.09 1-1/147 28.01.10 5 y

23	Shida-Kartli forestry division, Ckhinvali-Khomisi-Java section, Boshura (26, 27, 28)	424	Pine tree, Spruce_ 2239.3	Ltd. Jaga	1000032 (1000027 license was fully transferred by Murad Topchishvili) (100058 amendment In the license) (0000027 license was fully transferred by I.E. Lado – Murad Topchishvili	30.09.10 1-1/2916 29.12.09 1-1/1594 30.09.10 13/402 from 14.09.12 till 29.12.19- from 19.10.12 till 29.12.19-
25	Shida-Kartli region , Ckhinvali-Khomisi-Java section, Boshura 25,34,40,41 42	861	Pine tree, Spruce_ 3958	Nikoloz Javakhishvili 59001038038	0000025 (100058 part of the license was transferred by I. E. Lado	30.09.10 1-1/1593 30.09.10 10 y

26	Shida-Kartli region, Ckhinvali-Khomisi-Java forestry division, Boshura section 53 54	442	Pine tree, Spruce_ 1485	Ltd. Dilao	0000023 (100058 part of the license was transferred by I. E. Lado)	30.09.10 1-1/1591 30.09.10 10 yi
2010 year (license validity 10 years)						
№	Samegrelo-Zemo Svaneti forestry division, khaishi section, Chuberi (91.96-100.106-112)	1634	Beech_ 650 Fir_ 2375	I.E.Vakhtang Ubilava	100069	14.07.10 1-1/1175 13.07.10 5y
1	Kakheti, Akhmeta forestry division, Qistauri section #24	284	Beech - 320	I.E Beqa Oniashvili	1000023 (100067 license amendment	20.06.12 13/104 15.07.20 20.06.12

2	Imereti region, Vani forestry division, khumurI section (19-21,25-36)	1763	Beech - 2350 Alder tree - 150	Ltd. BEMONI	0000054	12.10.10 1-1/1672 12.10.10 10 Y
3	Racha-Lechkhumi Qveno Svaneti region, Lentekhi forestry division, khoduri section (27,28,35-42,46)	1342	Beech - 720 Coniferous - 900 Alder tree - 180	Emzar Mukbaniani	0000071	28.10.10 1-1/1730 28.10.10 10 Y
4	Shida-Kartli region Qareli forestry division. Zguderi section , 26.27.28	567	Beech - 280 Coniferous - 373	Guram gelashvili	0000079	29.11.10 1-1/1853 29.11.10 10 y
5	Racha-Lechkhumi Qveno Svaneti region, Lentekhi forestry divisionLentekhi (81,82,83,84,85)	858	Deciduous- 673 Coniferous) - 417	Ltd. Value Trading Corporation	0000091	18.01.11 1-1/25 12.01.11 10 y

6	Shida-Kartli region Gori Ckhinvali – khornisi – Java forestry division, Teni section 37.38.39	597	Coniferous- 280	Ltd. Albina	0000133	25.01.11 1-1/43 21.01.11 10 y
2011 year (license validity 10 years)						
1	Samegrelo-Zemo-Svaneti region, Khaishi forestry division, Ormeleti section #63 64.	247	Coniferous - 4070 Deciduous - 718	Ltd. Gruppo Via	1000001	13/302 10.08.11 11.08.2013-expired
2	Imereti region, Vani forestry division, Sairme Vani section (49-63 .)	1380	Beech - 650 Coniferous - 1250	Ltd. MERKANI	1000002 (0000094 license was fully transferred by David Denosashvili)	13/231 04.07.11 till 23.10.2020-
3	Samtskhe-Javakheti region, Adigeni forestry division, Kurckhuna section (9-21,26-31)	3013	Coniferous - 3333.3	Ltd. TAO	1000003 (100068 part of the license was transferred by Ltd.	13/304 12.08.11 till 24.07.2020

					Akhalcikhe	
4	Samtskhe-Javakheti region Adigeni forestry division, Gagvi section (1-24,26,27) Kekhovani section (1-14,19-23,25-28,30,32,33,35-38)	3856 da 4487	Coniferous - 6666.7	Ltd. Akhalcikhe	1000004 (100068 part of the license was transferred to Ltd. TAO	13/303 12.08.11 till 24.07.2020
5	Imereti region, Zestaphoni Kharagauli forestry division, Rikoti section #14;15	208.9 ha	chestnut tree	Ltd `T-Forest	1000005	13/354 07.09.11 till 08.09.2014-
7	Racha-Lechkhumi Qvemo Svaneti region Ambrolauri forestry division, LIkheti section (24,26,48,53)	517	Coniferous - 7603 Deciduous - 2040	Ltd. Caucasus wood resources,	1000029 (1000007 license amendment	10.10.11 13/430 04.10.11 13/434 24.09.12 till 05.10.21

8	Samegrelo-Zemo Svaneti region, Khaishi forestry division, Ormelati section 68,69)	254	Beech _ 250 Fir, Spruce,_ 1040	I.E. Anzor Kvaratskhelia	1000008 (100041 part of the license was transferred I.e. Maia Gelovani)	24.10.11 13/457 21.10.11 21.11.2014
9	Samegrelo-Zemo Svaneti region, Khaishi forestry division, Ormelati section (70.90.91)	427	Beech _ 711 Fir, Spruce_ 1912	I.E. Maia Gelovani3000 1004831	1000009	1-1/2699 20.11.09 24.10.11 13/458 21.10.11 21.11.201
10	Imereti region, Tchiatura forestry division, Gezrula section #7;9;10 .	553 ha	Chestnuts	Ltd. Wood Export	1000011	13/462 25.10.11 26.10.2016
11	Imereti region, Tchiatura forestry division, Gezrula section #11;14;18	542 ha	Chestnuts	Ltd. Wood Export	1000013	13/463 25.10.11 26.10.2016

12	Shida-Kartli region Gori Ckhinvali – khornisi – Java forestry division, Ormoci section 22.23.28.	548	Coniferous- 250	I.e. Giorgi Oqropiridze	1000014 (0000089 license amendment)	31.10.11 13/479 31.10.11 20.01.21
13	Shida-Kartli region Gori Ckhinvali – khornisi – Java forestry division, Boshura section 1.5.6	475	Coniferous- 250	I.e. Giorgi Oqropiridze ~	1000015 (0000092 license amendment)	31.10.11 13/480 31.10.11 20.01.21
14	Kakheti region, Kvareli forestry division, sections: Akhalsofeli, Kvareli, Shilda, Sabbue, Gremi	9 424	Beech - 7 500	Ltd. Georgian Group	1000019 (1000016 license amendment)	19.03.12 13/176 19.03.12 03.05.27
15	Samtskhe-Javakheti region, Akhalcikhe forestry division, Winaubani section #63	89	Coniferous- 50	Ltd. KUSHA 2011)	1000021 (1000017.)	11.04.12 13/632 11.04.12 27.10.28

16	Racha-Lechkhumi Qvemo Svaneti region Ambrolauri forestry division Nikortsminda section #11.	134	Coniferous - 8715 Deciduous - 635	I.E David Janelidze	1000025 (1000022 license amendment	06.06.12 13/60 06.06.12 13.08.12 13/302 07.06.15
17	Shida-Kartli region Gori Ckhinvali – khornisi – Java forestry division, Boshura section 35,36,37,43, 44	841	Coniferous_ 3893	Ltd. KOX 417877596	1000033 (1000030	13/812 17.12.12 13/524 10.10.12 29.12.19-
18	Samtskhe-Javakheti region, Aspindza-Akhalkalaqi forestry division, Aspindza section #13.	108	Coniferou I - 2 100 II - 900	Ltd. Buneba	1 000 031	17.10.12 13/528 17.10.12 17.10.13- Expired
2013 year						

1	Imereti region, Bagdati and Vani forestry divisions, Zekari section (#20-22,24,25,28-30,32-50); Tskaltashua section (#21-43); Soluri section (2-42,54,55,60-62,64,65); Sairme-Vani section (1-21,23); Zeindari section (15,17-25)	18 482 ha	volume - 24 621 m3 per year	Ltd. Georgian Wood and Industrial Development co.	1000037 (100001 Duplicate License)	09.09.13 1-1/2145 09.10.08 10.10.2
2	Kakheti region, Akhmeta forestry division, Ilto section (#36-39,45-93,96-98,102-104,108)	9 484 ha	volume- 10 078 m3 per year	Ltd. Georgian Wood and Industrial Development co	1000038 (100003 Duplicate License)	09.09.13 1-1/2144 09.10.08 10.10.28-
3	Kakheti region , Telavi forestry division, Fshaveli section (#42-46,58-65,70-80,88-92,100)	4 807 ha	Volume - 6024 m3 per year	Ltd. Georgian Wood and Industrial Development co	1000039 (100004 Duplicate License)	09.09.13 1-1/2142 09.10.08 10.10.28-

4	Kakheti region , Akhmeta and Tianeti forestry divisions, Akhmeta section (#17,18,23,24,30-34,36-42,44-51); Bochorma section (#1-6,13-16,24-27)	5 945 ha (	volume - 6431 m3 per year	Ltd. Georgian Wood and Industrial Development co	1000040 (100005 Duplicate License)	09.09.13 1-1/2143 09.10.08 10.10.28	
5	Mtskheta-Mtianeti region, Tianeti forestry division, Artaanis section s (#97-99,106-109,112,113,119,120,125,65-68,73-74,92-96,103-105,117-118,124,126,127); Akhalsofeli section (#1-26,29-31,32-34,37-45,50,58,59)	7 687 ha	volume - 9 080 m3 per year	Ltd. Georgian Wood and Industrial Development co	1000041 (100056 Duplicate License)	09.09.13 1-1/2146 09.10.08 1-1/2850 15.12.09 10.10.28	
6	Samegrelo-Zemo-SvanetI region, Tsalenkikha and Chkhorowkhu forestry divisions, sections: Mukhuri, Taia, Nafichkhovo, Khudoni, Jvari, Magana.	37 858.829115 ha	636 000 m3	Ltd. Georgian Wood and Industrial Development co	1000042 (00628 license amendment)	01.10.13 13/164 12.03.12 470 03.05.07 04.05.27-	

Annex II. Volume of round wood processed by sawmills from January 2013 to August 2014

Region	N	Municipality	2013 year	January -14 August 2014
Shida-Kartli	1	Khashuri	4 230.04	1 056.82
	2	Qareli	1 726.69	1 010.67
	3	Kaspi	12.34	4.85
	4	Gori	3 008.53	934.58
		Total	**8 977.60**	**3 006.91**
Mtskheta-Mtianeti	5	Tianeti	44.88	15.20
	6	Dusheti	-	96.00
		Total	**44.88**	**111.20**
Samtskhe-Javakheti	7	Bordjomi	675.76	291.65
	8	Aspindza	2 036.70	190.64
	9	Adigeni	4 690.79	2 970.86
	10	Akhalcikhe	3 857.52	1 063.86
		Total	**11 260.76**	**4 517.01**
Imereti	11	Khoni	86.11	68.76
	12	Tkibuli	139.06	266.37
	13	Tchiaura	1 499.71	356.20
	14	Sachkhere	6 242.15	945.72
	15	Vani	749.65	277.75
	16	Bagdati	1 017.74	709.61
	17	Zestafoni	63.23	107.37
	18	Kharagauli	64.73	67.52
	19	Wkaltubo	44.50	1.50
	20	Terjola	1 043.48	1 412.44
	21	Samtredia	50.67	22.40
	22	Kutaisi	12 942.84	156.48
		Total	**23 943.87**	**4 392.12**
Guria	23	Ozurgeti	180.10	210.49
	24	Lanchkhuti	598.44	127.20
	25	Chokhatauri	1 867.16	466.67
		Total	**2 645.69**	**804.36**
Racha-	26	Ambrolauri	6 316.01	22 997.54

Lechkhum Qvemo Svaneti	27	Oni	2 654.01	111.91
	28	Lentekhi	764.94	78.06
	29	Tsageri	451.84	38.05
		Total	**10 186.80**	**23 225.56**
Samegrelo-Zemo-svaneti	30	Mestia	15 011.23	2 472.27
	31	Martvili	6 344.33	1 349.82
	32	Chkhorowkhu	392.44	506.07
	33	Tsalenjikha	7 406.91	2 593.80
	34	Zugdidi	2 536.05	900.25
	35	Abasha	477.13	313.79
	36	Khobi	257.31	179.10
	37	Senaki	443.19	553.33
	38	Foti	2 575.89	255.12
		Total	**35 444.49**	**9 123.54**
Kakheti	39	Sagaredjo	38.89	33.74
	40	Lagodekhi	90.90	232.88
	41	Kvareli	1 420.34	1 633.82
	42	Telavi	479.69	419.47
	43	Akhmeta	874.04	410.03
		Total	**2 903.87**	**2 729.94**
Adjara	44	Qobuleti	1 050.27	1 090.09
	45	Khelvachauri	1 151.12	1 641.26
	46	Qeda	120.34	146.97
	47	Shuakhevi	3 945.57	443.72
	48	Khulo	776.76	250.04
		Total	**7 044.06**	**3 572.08**
Tbilisi	49	Tbilisi	215.03	475.60
		Total	**215.03**	**475.60**
Georgia Total			**102 667.05**	**51 958.31**

Annex 3

Interviews

	Date	Name	Organization/position	Main topics discussed	Comments/findings
1	01.07.14	Leri Chochua 599913066	Forestry agency	TOR for forestry experts	
	21.08.14 Telephone interview	Dr. Zurab Jinjikhadze	Agro-Company ”Lomtagora” Corn breeding Expert	Corn cultivation; Corn residual biomass production and ratios (RPR - Residue to Product Ratio; RCA - Residue-to-cropping-area)	Corn types and production quite differs by regions of Georgia; e.g. in Estern Georgia most common corn vatieties are “Kartuli Krugi” which grows up to 3.2 m. in height, another is “ Kaja Kviteli’ grows up to 2.2 m. In the Western Georgia the most common vatieties are “ Aajmetis Tetri” and “Abashuri Kviteli’ both are popular too much and growing up to 3.5- 3.8 m. in height. Corn varieties in Georgia can produce 6 Mt/ha of residual biomass on average.
2	21.08.14 Telephone interview	Dr. Zaur Julukhidze	Agro-Company ”Lomtagora” Cereal production Expert	Cereal cultivation; Cereal residual biomass production and ratios (RPR - Residue to Product Ratio;	The cereal RPR makes up 1:1 straws to grain. Cereal varieties in Georgia can produce 3 Mt/ha of residual biomass on average.

				RCA - Residue-to-cropping-area)	
3	21.08.14 Telephone interview	Goderdzi Goderdzishvili	CARE International in Caucasus; Agriculture Consultant	Various annual crop productions.	Annual crop residual biomass production basically depends on varieties, climatic conditions, and agro-technology processes.
4	22.08.14 Telephone interview	Bondo Bolgashvili	Head of MoA agriculture information center of Dedoplistskaro municipality (Kakheti region, Eastern Georgia)	Sunflower cultivation; Sunflower residual biomass production and ratios (RPR - Residue to Product Ratio; RCA - Residue-to-cropping-area)	The sunflower RPR makes up 3:1 straws to grain. Sunflower varieties in Georgia can produce 3.5 Mt/ha of residual biomass on average.
5	23.08.14	Malkhaz Talakhadze	Multi-year experienced farmer from Giorgitsminda vill. Akhaltsikhe municipality (Samtskhe-Javakheti region, Southern Georgia)	Cereal and potato production.	The wheat can produce 200 (+ / - 20) pressed bales per hectare.
6	23.08.14	David Gigitashvili	Corn, vegetable and vine production.	The corn stover makes up 115	

		Multi-year experienced farmer from Kvishkheti vill. Khashuri municipality (Shida Kartli region, Eastern Georgia)		packs per 1000 m^2 (30 each straw per pack)	
7	05.09.14	Temu Kuridze 577115184	Head of Ajara AR Forest Agency		
8	01.09.14	Zaal DauSvili 595163861	Geographic Ltd.	Forest inventory and planning expert	
9	27.08.14	Malkhaz Rogava 571888819	Georgia Wood&Industrial Developoment Ltd.	Forestry Expert	
10	08.07.14	Shota Gongladze	Ministry of Agriculture, Deputy head of department	Work Organization, Ministry information centers, organic agriculture	
11	09.07.14	Manana Tsulaia	ELCANA, Lead Specialist	Recruiting the experts and goals of the project	Bio-Agriculture experts are against removing agricultural residues from the fields

12	11.07.14 Telephone interview	Nukri Memarnishvili	Head of Marneuli Information center	Annual crops and their residues, vegetables	Sunflower and even tomato residues may be considerable
13	19.09.14	Hans Keller Olga Weigel	GIZ, International Agriculture Expert	Western Experience in Biomass energy use. Local conditions.	Shirakiwheat residues could be used for energy without damage to soil.
14	20.08.2014	Otar Kurtiashvili	TELAVI WINE CELLAR, consultant. Investigator at IHVO	Local experience of vineyard pruning residue using	Farmers use cuttings from vineyards as a heating resource, whereas big companies prefer to burn vine residue near the field.
15	20.08.2014	Joni Shonia	Information-consulting center of Khobi municipality, MOA	Local experience of bay leaf and hazelnut pruning residue using	Bay leaf residue is not used as an alternative heating source by local farmers. Assimilation of bay leaf residue is difficult without breaking up of stems, because bay leaf is ether bearing plant and its stems contains high quantity of ether-bearing oil. Farmers, with access to breaking machinery use bay leaf residue in the same cooker, which is used for hazelnut shells.
16	21.08.2014	Zviad Bobokashvili	The Scientific Centre of Agriculture, MOA. Perennial crops' specialist. Director of the Horticulture Institute	Local experience of fruit orchards' pruning residue using	Apple pruning technique is most common in newly established orchards in Shida Kartli

17	22.08.2014	David Picha	International fruit expert at NEO/USAID	International experience of fruit orchards' pruning residue using	Many fruit (apple, pear, peach) growers in Georgia do not train their trees (pruning) after planting and neglect to annually prune the trees during the winter. To inform farmers regarding advantages of pruning will improve the orchards and give opportunity to use alternative energy to fruit-growers. Pruning will help to plant to grow better, accordingly – increase harvest.
18	23.08.2014	Levan Ujmajuridze	The Scientific Centre of Agriculture, MOA. Head of the center	Local experience of vineyards' pruning residue using	Transportation and storage cost are much higher for local farmers, then value of alternative heating source
19	23.08.2014	Bruce J. Bailey	F2F international consultant of hazelnut and bay leaf	International experience of hazelnut and bay leaf pruning residue using	Ratio for leaf and stems in bay wet leaf yield is 2:3. Based on this information have been calculated the following data: **1 TREE PROVIDES 0.83 KG DRIED LEAF;** **1 HA – 5 TON DRIED LEAF;** **1 TREE PROVIDES 2.5 KG WET STEM;** 1 ha – 15 ton stem.
20	24.08.2014	Guram Aleksidze	The Academy of agricultural sciences of Georgia, president	Perinea crops' pruning	
21	24.08.2014	David Magradze	Director of Viticulture and Oenology Institute	Local experience of vineyards' pruning residue using	Vineyards' crop residue hesitates between 2-3 t/ha

22	25.08.2014	Goga Svimonishvili	Head of Agrokartli, Ltd. Farmers' Service Centers supported by USAID	Local experience of fruit orchards' and vineyards' pruning residue using	Residual biomass potential from agriculture in Georgia consists of pruning of vine and fruit orchards, that are generally cut up and then land-filled, or burned near the field, with additional costs for farmers and serious problems about parasites development or uncontrolled fires
23	25.08.2014	George Javakhishvili	Specialis at CNFA, REDP	Local experience of fruit orchards' pruning residue using	Fruit orchards are not pruned in Samtskhe-Javakheti region
24	26.08.2014	Nodar Khokhashvili	Head of the division of Sectoral development, MOA	Area under perinea crops	Double-checked data from GeoStat
25	26.08.2014	Nikoloz Kiknavelidze	Information and Consultation centre of Mtskheta municipality	Local experience of fruit orchards' and vineyards' pruning residue using	Fruit orchards are increasingly unproductive and unprofitable due to the significant ages of the orchards, traditional growing methods, outdated varieties limiting fruit yields and market alternatives
26	26.08.2014	Maia Mikava	Director of the hazelnut producer company, EuroNats.	Local experience of hazelnut and bay leaf pruning residue using	Farmers use hazelnut shells residue for heating
27	26.08.2014	Nugzar Ioselani	The Aroma Company, Ltd's Bay/Dafna, specialist	Local experience of hazelnut and bay leaf pruning	Georgian harvesting is done manually from early October through the end of March. The 2-year-old plants being harvested are cut near the base of the plant just above where lateral branches have

				residue using	established, roughly 6-8 centimeters above ground level.
28	26.08.2014	Nana Mirotadze	LLC Ferero International	Local experience of hazelnut pruning residue using	Hazelnut generates residues in the form of fronds and shells. About 10 fronds are shed per tree per year, yielding about 1.4 kg. dry woody biomass per frond or, assuming a density of 200 trees per ha, about 2,800 kg. per ha.
29	27.08.2014	Tamaz Dundua	Elkana	Local experience of hazelnut pruning residue using	Hazelnut shells are generally used as an alternative heating source in cities and suburban areas of the Samegrelo and Guria Regions of Georgia, where most of the nuts are grown and harvested.
30	29.08.2014	Giorgi Iakobashvili	CNFA	Area under hazelnut orchards	The buyers of hazelnut require for hazelnut shell/product ratio not more than 60/40.
31	01.09.2014	Davit Tamarashvili	Vine and Wine Group Ltd. Director	Local experience of vineyards' pruning residue using	Vineyards' pruning residue is not used as an alternative heating source. Most of the residues are left in the field or burnt.
32	01.09.2014	Celal Tuncer	International expert of hazelnut, NEO/USAID	International experience of hazelnut pruning residue using	Hazelnut shells burn so quickly, they immediately turn into ash, and thus, it is not possible to use the heat produced by them efficiently.

Annex 4

Residue Heating Value

	Crops	**Heating value MJ/Kg**
	Perennial crops	
1	Vine pruning	18.4
2	Fruit orchard residue	18
3	Hazelnut	18.7
4	Hazelnut shells	18.7
5	Bay leaf	19
	Annual crops	**Heating value MJ/Kg**
1	Wheat	16.92
2	Barley	16.92
3	Corn straw	17.71
4	Kidney bean	13.68
5	Sunflower	15.80
6	Oat	16.92
	wood	**Heating value MJ/Kg**
1	Energy value accumulated wood	14.7
2	Energy value Annual potential	9.8

Conversion Units

1 kWh	= 860 kcal	= 3,600 kJ (3,6 MJ)
1 MJ	= 239 kcal	= 0.278 kWh
1 kcal	= 4.19 kJ	= 0.00116 kWh