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მსოფლიო გამოცდილება საქართველოსთვის
WORLD EXPERIENCE FOR GEORGIA

Assessment of Wood and Agricultural Residue Biomass Energy Potential in Georgia

FIELD STUDY

UNDP

Prepared for UNDP under

Micro-Capital Grant Agreement for Non-Credit Related Activities of 28.11.14

Field Survey of Potential for Biomass Use for Energy in Georgia and Promotion of Biomass Use through Website

Contents

Abbreviations

GIS	Geographic Information System
ILIAUNI	Ilia State University
MENRP	Ministry of Environment and Natural Resource Protection of Georgia
MoA	Ministry of Agriculture of Georgia
NFA	National Forestry Agency of Georgia
UNDP	United Nations Development Program
WEG	World Experience for Georgia – Energy and Environment think-tank

Executive Summary

In 2014 WEG conducted a desk study to evaluate the amounts of residual solid biomass potentially available for energy use. Two main categories of biomass were studied – biomass coming from forestry operations including the remains of tree trunks and branches in the forest, sawdust accumulated after primary and final cutting of the timber, the young trees and bushes potentially available after the early tending and trimming as well as the cuttings in support of forest development. Under agriculture component residues from annual and perennial crops were considered this included orchard and vineyard cuttings, hazelnut and bay leaf production residues as well as annual crops like corn, wheat, barley etc. most developed in Georgia. The study revealed a substantial potential of residues that might be sufficient for commercial development and effective use in the modern biofuel production like pellets, briquettes, chips etc.

As a follow-up to theoretical desk study, it was decided to conduct the field assessment of practically available biomass. The main goal of the field study is to justify the results of a desk study, examine the current biomass residues usage, assess the residue collection costs and identify the potential of commercial development. This report shows the results of the field study conducted by WEG together with Institute of Energy and Sustainable Development at Ilia State University.

The study was planned and implemented based on the findings of the phase 1.Research methodology for the study included field visits to forestry and agriculture sites, interviews and focus groups with farmers and Entrepreneurs as well as representatives of Regional Information-Consultation Centers (RICC) of the Ministry of Agriculture (MoA), Amenity Services at municipalities and the National Forestry Agency (NFA) of the Ministry of Environment and Natural Resources Protection (MoENRP). RICCs and NFA served as the main information sources at the initial stage of the project.

The initial information from the desk study was verified and extended through telephone inquiries and additional information from the NFA and RICCs to identify the locations and production volumes of operating businesses and to agree with them the visit times.

Questionnaires were prepared for the field visits. They contained the following main classes of inquiry questions:

General information

- Business location (region, district, address, GIS references, owner)
- Contact person interviewed (name, position)/ Date of establishment
- Basic machinery type/ Number of employees
- Volume of production
- Plan for future operation of sawmill based on: Existing contract/contracts and Private orders
- Quality of access roads

Specific information

- Volume of biomass residues left after primary processing
- Volume of residues left after secondary processing of

- Total volume of residues accumulated per year
- Volume of sawdust and other sawmill residues accumulated during previous years

Assessment of residues

- Condition of waste in place by categories (fresh, wet, Dry – Rotten)
- Current practice of waste disposal
- Approximate volume/weight accumulated at the moment of interview
- Willingness to give the residue to third parties
- Etc.

Residues from forestry operations

The following categories of forestry residues were considered: 1. Sawdust available from sawmills, 2. Residues remaining in forests after licensee operations, after illegal cuttings, and after natural or man-induced disasters 3. Residues potentially available after tending and thinning as well as bush removal in support of forest succession.

Residues from sawmills

For sawmill survey more than 120 sawmills with the annual timber processing volumes in excess of 100m^3 were preliminary enquired, and finally 69 sawmills, currently operating in six regions of Georgia were selected and visited. Interviews were conducted by the young specialists of Ilia State University. Interviewers used special questionnaires which was designed to collect the following information:

Special equipment for wood moisture measurements was used to assess the moisture of sawdust at initial stages of the project. Based on agreed measurement methodology for the assessment of sawdust and woody biomass moisture content, the group orientation and training was conducted. However it became clear that the moisture content varies significantly on each site and from site to site and depends strongly on the time since production, precipitation and storage conditions. This variety limited the value of measurements in each particular case and saw dust condition was categorized (fresh, wet, dry and rotten).

The survey confirmed that there is a large accumulation and significant annual addition of sawdust in various regions of Georgia where this sawdust can be used for production of advanced solid fuels. Taking into account that spatial distribution of sawmills, respective wood resources, accessibility, etc, would play a significant role – GIS[1] was selected as tool for data collection, visualization and analysis.

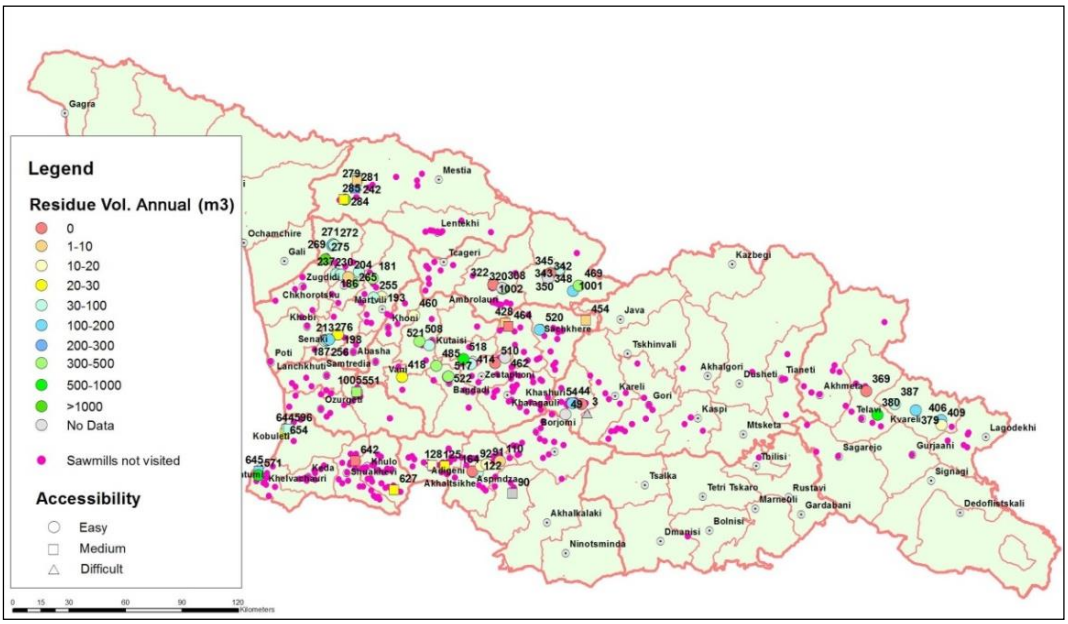
Landsat Thematic Mapper (TM) data with suitable spectral and spatial resolution and relatively long time series of data availability have made it a primary data source for biomass estimation. High resolution aero-

[1] GIS component of Survey aims obtaining the precise geographic coordinates of sawmills location in general and creation of the geo-database with the structure suitable for further geospatial analysis of collected data.

photogram-metric shooting of selected Forest sites was used as a ground truth for general resolution products derived from Landsat Multispectral image. Field Aerial photo shooting was conducted at specified sites during the months of May and June of present year (2015). Derived high resolution ortho-photos were used to assess the forest condition and amount of available residual biomass per area. For more details please see corresponding report.

Total amount of sawdust and other wood residues at the territories of interviewed sawmills is estimated at around 32 thousand m^3. In many cases it is difficult to distinguish them by hardwood and coniferous since they are mixed in disposal area. About 25% of total amount of residues from sawmill operations is sawdust and fines and the rest (75%) consists of slabs, edgings, off-cuts and bark. More than 90% of waste in place is in condition appropriate for further use. The sawdust accumulated in place in most of the cases has high moisture content. Sawdust of substantial thickness preserves the high moisture content in the range of 40% even after several months on the open air.

The highest accumulation of sawdust was found in Adigeni, Sachkhere and Kutaisi municipalities, where the amount of sawdust exceeds several thousand cubic meters. The sawdust is being accumulated for decades and is partly deteriorated. High concentrations and high volumes of sawdust are available in Svaneti Mestia, Khaishi and Chuberi region. This is the only place where the sawdust is not being used for heating and is considered as merely waste. The remote location and lack of transparency in sawmill operations makes it challenging for outside investors. In Chuberi there are more than 15 sawmills, however it was only possible to talk to three. Others refused to provide the information. The amount of available residual sawdust is indicated in the map below. The color and form indicate the amount of sawdust and road accessibility of sawmills.



PICTURE 1 - PIC 1. SAWDUST AVAILABILITY IN GEORGIA – ANNUAL VOLUMES

A more detailed information about the exact locations and available sawdust amounts can be found on interactive maps at the website – www.biomass.ge

Machinery used in sawmills is mainly simple and outdated, only a few factories are equipped with more advanced technique, these are sawmills owned by long term (20 year) licensees. It is evident that most of sawmills suffer from the shortage of raw material which causes their unstable operation. Seasonal interruption in round wood supply is due to seasonal inaccessibility of the forests where this wood is being harvested.

Management of waste products at sawmills is an important problem that sawmill administration/owners would like to solve. According to survey results there are different approaches currently used by sawmills:

1. Burning at the territory -5%
2. Disposal at the sawmill territory for further decay – 5%
3. Transfer to local population (free of charge) -6%
4. Selling to local population – 3%
5. Disposal out of the sawmill territory – 12%
6. Disposal at the special landfill – 30%
7. Use by sawmill for heating and drying of their wood products – 31%
8. Further processing for briquettes – 8% [2]

Taking into account that there are around 600 officially registered sawmills not surveyed, also a high amount of illegally cut and processed wood, the final amount of available sawdust and other wood residues should be considerably higher. Waste disposal is subject to strict regulation and poses problems to sawmill owners. Many of them have been fined by forestry agency. Most of sawmill owners agree to cleaning-up their territories from waste by external parties and may be ready to provide it free of charge.

There are several cases when the sawdust is being used for production of briquettes or pellets:

- Kula company is collecting waste from the Gverdzineti (Kareli) sawmill #3
- In Akhmeta there is a small briquette factory which however has the problems due to poor quality of equipment
- In Khaishi (Svaneti) the sawmill has started briquette production, however the Chinese production machine is not suitable to the fine sawdust, therefore the owners are trying to adjust the equipment to local condition by replacing some parts

In most cases the operation is not successful either due to poor equipment or marketing.

Waste Biomass from Forestry

In the planning phase of the project the project team obtain the detailed information from relevant state institutions (Central and local offices of the Environmental Supervision Department and National Forestry

[2] (there are many simple factories producing briquettes established in different regions, see photo below: briquette producing factory in Akhmeta)

Agency) on wood residues accumulated in the forests and on the locations where alternative woody biomass might become available from early tending & thinning and the measures in support of natural regeneration. Based on analysis of the received information and accessibility of the sites the priority regions were selected for further field works.

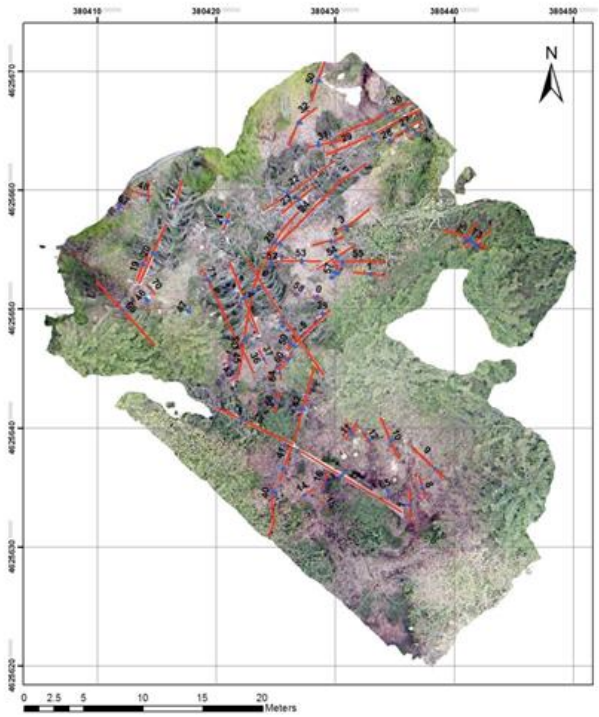
For the field assessment of wood residues in forests it was decided to use aerial photography already being applied in Ilia State University for Geology and Biodiversity applications. Methodology included estimating of the quantity of bio-degradable Material (Biomass) in the forest through Photogrammetric. For this task UAV (Quad-copter Dji Vision Phantom 2) and a remotely operated camera (Nikon Coolpix AW 110) adapted to android system were used. Photos taken from the aerial were processed in a special software package (AgiSoft PhotoScan Pro 1.1.4), points were georeferenced and photos were matched to each other to create a complete synthetic image of the whole area.

The geometrically correct images were used to measure the objects of interest (logs, tree trunks, big branches). The procedure also included assessment of the quality of the remaining wood residues by cutting the samples on a scale of good/marginally useful/deteriorated and the measurements of moisture content were also conducted.

The typical forest sites were selected in the following locations:

- *Kvemo Kartli region – Martkopi forest unit. wood waste is originated from illegal cut in 2011-2012 by local population.*
- *Shida Kartli region – Khashuri forest unit. Wood waste origin is timber harvesting by license holder.*
- *Samtskhe-Javakheti region – Borjomi-Bakuriani forest unit. The area presents combination of broad leaved and coniferous forests with wood waste after illegal cut and trees felled by wind.*
- *Samtskhe-Javakheti region – Borjomi-Bakuriani forest unit. Big territory (900 ha) burned after armed conflict in 2008 with plenty of trees left.*
- *Shida Kartli region – Khashuri forest unit. Surami Forest unit with high coverage of evergreen bushes.*

The typical picture from Borjomi-Bakuriani damaged forest site is presented below.



PICTURE 2 - FOREST SITE IN MITARBI, SAMTSKHE-JAVAKHETI REGION – BORJOMI-BAKURIANI FOREST UNIT

After cleaning of these forests approximately 50 000 m^3 of wood biomass might be generated (it is estimated that one hectare gives around 10-15 m^3 wood).

The results of previous desk study 3 and the field survey suggest the **Samegrelo-Zemo Svaneti, and Imereti** as priority regions with higher potential of wood biomass: Annual timber harvesting (industrial and fuelwood) in Samegrelo Zemo Svaneti is equal to 158 thousand m^3 which will accumulate about 56 thousand of wood waste, and in Imereti 176,6 Thousand m^3 accumulating 62 Thousand m^3.

The cost of collecting the wood waste from forests is significantly higher. The estimated cost of hiring the local trucks e.g. in Khashuri area for the 10-15km forest roads at off-season is about 300-400 GEL which makes collection of waste biomass even in late spring-early summer questionable. The fuel economy of KRAZ trucks used in the forests is about 45-50 lit/per 100km. Even if doubled due to poor road conditions this translates into 40-50 GEL for fuel per a trip to-from forest site at 10km distance. With own truck such a trip could cost around 100-150 GEL.

Existing legal framework needs to be revised to allow business companies to collect wood wastes.

An attempt was made to use the satellite images for assessment of available biomass in the forests in different parts of Georgia. Two main indeces – the vegetation index and water content index were used for relating the multispectral data to the volumes of available residual biomass in place. The correlations found indicate that the method requires further development and has the potential to produce practically useful results.

3 “Assessment Of Wood And Agricultural Residue Biomass Energy Potential In Georgia”, WEG, 2014 http://weg.ge/wp-content/uploads/2012/01/FINAL.pdf

The information collected on various sites was entered into the GIS database and can be made available on demand.

Agricultural residues

Another important source of biomass is agricultural residue from annual and perennial crops. In terms of energy content, waste from agricultural production is highly significant source. Today these sources are utilized on a wide scale in many countries including developing countries.

The study of agricultural residues included interviews and focus groups where in total, 88 - Farmers and representatives of 7 Regional Information-Consultation Centers of the Ministry of Agriculture (Telavi, Kvareli, Gori, Sagarejo, Zugdidi, Gardabani, Dedoflistskaro) as well as 5 bay leaf producers were interviewed. In addition Interviews with the management of some of the leading wineries in Georgia have been conducted.

Vine and fruit cuttings

Vineyards have the highest share of residue in perennial crops. Generally, 3.2-3.5 tons of vine pruning residue is available from 1 ha according to various respondents. This number is about 15-20% higher than the estimate of the desk study. Based on the interviews with some 40 farmers, 643 tons of waste is available annually for alternative use. All interviewees confirm that they burn about 90% of vine cuttings immediately after removal from the vineyards. The cost of collecting the residues from a hectare of vineyard approximately 40GEL or 1 GEL per 100m row. The average size of vineyard is about 10-15 ha therefore the most frequently mentioned total cost of collecting and di for the according to waste disposal varies and costs approximately 400-600 GEL.

There is lack of information about potential residue alternative use. 80% of respondents do not have any information about possible ways of waste recycling. 100% of the respondents say though that they would be interested and would cooperate with third parties on waste disposal. In most cases they have expressed the readiness to give up the residue for free.

As of **fruit orchards**, 3.5 tons of pruning residues are left from 1 ha. 25 farmers with 104.4 hectares fruit orchards were interviewed from which 365 tons of waste can be accumulated annually. Residue from fruit orchards is also burned near the field. The cost of waste collection is about 300-400 GEL per average orchard of 10-15 hectares.

Winery wastes

Interviews conducted with the management of leading wineries have shown an interesting potential of pomace biomass generated after pressing the grapes.

TABLE 1 - RESULTS OF INTERVIEWS WITH SOME LEADING WINE PRODUCERS IN GEORGIA

Name of winery	Total (own) Amount of grape processed tons	annual accumulation of pomace (tons)	Accumulated	Willingness to dispose
Bagrationi 1882	2000	600	Huge reservoir overfilled	Yes
Badagoni	1000 (500)	300	500	Yes
Telavi Wine Cellar	5000(3000)	1500	1000-1200	yes
Armunji (Kindzmarauli Corporation)	1000-1200	300	Fertilizer for own vineyards	No
Shukhmann wineries	700-1000	18%	Fertilizer for own vineyards	No

Hazelnut

Hazelnut shells are generally used as an alternative heating source in cities and suburban areas of Samegrelo and Guria. 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 however, respondents mention, that usage of hazelnut residue decreases gradually because of the gasification process. However there is an emerging market for shells for other business purposes.

Bay-leaf

There is a growing demand for bay leaf from regional and the international markets. Farmers are reviving bay leave growing and harvesting, while some private entrepreneurs have set up collection and processing business. Bay is mainly spread in - Samegrelo, Guria and Imereti. Samegrelo is the major producing region, with 70-80% of production concentrated in Khobi municipality.

According to 5 bigger producers in Khobi, all of them produce 800-1000 kg residue daily, (about 1000 tons annually from the interviewed businesses only). 25-30 kg batches leave 5-6 kg of bay leaf and about 10-12 kg of residual fine branches after drying and separation. These small braches are inconvenient for direct burning. Bay leaf producers are shredding about 30% of these remaining dry fine branches and use as a fuel for leaf drying the remaining 70% is burned in vain. The burning process of chips is inefficient and incomplete.

Additional information was collected about 20 businesses from the local consultation centers. These businesses produce 128 tons of bay leaves on average (about 2500-2600 tons of leaf in total), and produce 250-260 tons of residue out of which Estimated 70% -or about 170 tons is burned in vain.

More than 3500 tons of residual biomass can be available only in Khobi municipality, higher than expected from desk study. If the burning efficiency of driers improves, even more residual biomass will become available.

Annual crops

Corn straw – The inquiry was used mainly to determine the current use of corn residues. According to the study, 2.6 tons of corn stover is accumulated from 1 ha. Totally 1313 ton of residue is available annually from corn. However, this is fully used as animal feed and is not available for fuel production.

Wheat straw – According to respondents the wheat straw is being used for animal feed and bedding it is not available for other uses. Only Dedoplistskaro RICC reported leaving about 50-60% of straw and burning it in fields. As a result the fires are deteriorating the soil and have caused the wind break fires.

Sunflower – According to five RICCs in Kakheti the sunflower seeds are harvested by special machinery that takes only the seeds and leaves the remaining plant biomass in the field. These residues are left in the field, burned or most commonly ploughed into the ground next year. The amount of yield 4.5 – 6 t/ha crop residue and 1.5–2 t/ha seed yield from the theoretical study was roughly confirmed. The area under sunflower is much higher than in theoretical study and approximates 14000ha.

Total energy available from Residual Biomass in Georgia

Type of Biomass residue	Total area (ha)	Residue (kg/ha)	Heating value (MJ/kg)	Energy Production (MJ/ha)	Annual Energy Production (TJ/annum)	Accumulated Energy (TJ)	Total Energy Production TJ	Field study checking
Vine residue (pruning)	33000[4]	3300	18.7	61710	2036		2036	Available
Fruit orchards'	59000[5]	3500	18	63000	3717		3717	Available
Hazelnut (shell)	15000	3600	17	61200	918	-	918	Available
Bay-leaf	600	15000	19	285000	171	-	171	70% available
Wheat straw	44900	3000	16.9	50700	2276	-	2276	Mostly not available
Sunflower	14000	4500	14[6]	63000	882	-	882	Can be available
Corn Stover	150000	6900	17.7	122130	18300	-	18300	Not available
Total (TJ)							**28300**	
Total available (TJ)							**7673**	**Available**

[4] http://www.geostat.ge/cms/site_images/_files/georgian/agriculture/AG%20Census%20Release_2016.pdf

[5] http://www.geostat.ge/cms/site_images/_files/georgian/agriculture/AG%20Census%20Release_2016.pdf

[6] http://elibrary.asabe.org/abstract.asp?aid=30844&t=2&redir=&redirType=

Energy Potential of Grape Pomace and Hazelnut (shell) from Exemplary Factories

Vinery – grape pomace	Heating value (MJ/kg) - 16[7]	From 1000 tons of grape 300 tons of pomace is produced.	2400 tons of pomace is produced annually from 3 vineries. (Badagoni, Telavi, Bagrationi 1882)
Hazelnut (shell)	Heating value (MJ/kg) - 17[8]	40-50% of total hazelnut amount is residue	Annual production – 50-60 thousand tons

Energy Potential of Forest Residue in Georgia

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**
Social cut	**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**

[7] http://produkcja.ipan.lublin.pl/uploads/publishing/files/Burg30%202.pdf

[8] http://www.utalca.cl/english/noticias/hazelnut_biofuel_15.html

Sawmills	**227 000**	**2.4**	**36 000**	**0.3**
Early & Mid-term Tending and Thinning			**250 000**	**1.8**
Measures to support natural regeneration	**75 000**	**0.5**		
Sub Total	**302 000**	**2.9**	**286 000**	**2.1**
Total	**3 188 000**	**31.7**	**1 086 000**	**8.2**

Conclusions

There is a significant amount of unutilized biomass residue available in Georgia which can be successfully used for pellets, briquettes or other types of modern biofuels.

1. *From agriculture the following crops have high potential:*
   - **Vineyard and orchard pruning residues** - The amount of vine cutting residues is higher than estimated in the desk study by some 10-20% and amounts to 3.2-3.5 tons per hectare. 90% is being burned soon after cutting in early springs.
   - **Winery residues –** several big wineries have annual accumulation of pressed pomace of several hundred tons and have difficulty of its disposal
   - **Bay fine branches** remaining from bay leaf harvesting with high concentration in Khobi municipality.
   - To a less extent **wheat** (mostly in Kakheti- Dedoplistskaro) and potentially the **sunflower.**
   - The residues of other crops have alternative uses and are less likely to be available for energy.
   - Most farmers are paying for removal of residues from their orchards and wineries and will be glad to have some sort of alternative resolution for waste disposal.
2. *From Forestry operations*:
   - High accumulation **sawdust** and potential annual addition has been observed in sawmills in several regions of Georgia. The amount of available sawdust varies between several hundred to several thousand cubic meters with variable quality and mostly high moisture content of about 40%. The detailed maps with indication of potential amounts and accessibility are available on website www.biomass.ge. The full GIS database is available on demand.
   - High amounts of **remaining tree trunks, big branches and logs** have been found in the areas of illegal cut that are left in place as physical evidence and are not allowed to be used by population. The estimated amount is about 4-5m^3/ha. Less amount is available from licensed territories.
   - **Residues potentially available from bush removal**. The field estimates indicate that bout 10 m^3/ha of biomass can be obtained by removing the Rhododendron bushes which may result in 50000m^3 of biomass available from 5000ha of territory 80% dominated by these bushes.
   - There are estimated several thousands of cubic meters of **tree trunks accumulated in Enguri HPP reservoir**, that can be used as a fuel, however there is no permission to collect and use this biomass
3. *Costs of waste removal*
   - The typical cost of removal from the hectare of orchard or vineyard is about 40-50GEL.
   - The daily worker hiring costs 25 GEL in East Georgia regions
   - The cost of cleaning up the average vineyard of 10-15 ha is 400-600GEL while for orchards in Kartli 300-400GEL
   - One route to the forest with the big three driving axes Ural truck costs 300-400 GEL
4. *The study has revealed several inefficiencies in biomass residue management causing problems to owners and resulting in environmental damage:*
   - Lack of legal disposal sites for sawdust from sawmills and associated fines are causing the owners to store the sawdust in their territories, burn it illegally or cause significant damage by disposing in river gorges.
   - Common problem is burning of residual biomass from perennial and annual crops. This includes burning of the big amounts of orchard, vineyard cuttings and fine bay branches; field burning of remaining stems and roots of wheat and barley. In many cases this is illegal but also causes damage to the fields.

- Residues of a number of big wineries are left in the open air and are accumulating causing logistics and disposal problems to the owners.
- Burning causes GHG emissions without any accompanying energy benefit.

Developing of solid biofuel production could avoid these useless emissions and local environmental damage, and allow to produce the energy in a sustainable way.

Recommendations

- Legal treatment of illegal cuts in forests should be made more flexible to allow utilization of the residues
- The feasibility of chipping and removing the residues from forests needs to be studied for tending and trimming, bush removal and residues of tree harvesting
- The forestry agency should promote the early tending and trimming operations as well as bush removal and could combine this with production of biofuel production from residues thus combining the environmental and forestry benefits with energy production.

1. Background

Under the capital grant agreement with UNDP, WEG has conducted a desk study of residual biomass energy potential available from forestry and agriculture operations in Georgia.

The study was conducted for the following main biomass categories: 1. woody biomass from wood processing operations, 2. woody biomass potentially available from forestry operations, such as timber harvesting and forest tending, 3. biomass residues of perennial agricultural crops and 4. Biomass residues from annual crops.

The study estimated the types and the volumes of accumulated residual biomass and their regional distribution. The priority regions were selected and the highest energy potential biomass types identified for further field studies. The findings of the study indicated that there is an important untapped potential of residual biomass that can be utilized to provide heating means to various consumer categories.

In order to verify the findings of the desk study, to confirm the actual available amounts of residual biomass and identify the locations with its high concentration, as well as understand the current practice of waste disposal and willingness to share it for energy use, it was decided to conduct a field study and to visit the places with the highest expected volumes of available waste. This technical report provides the results of field assessment conducted as a follow-up to the desk study according to main biomass categories.

The study was implemented by WEG with the participation of Agriculture and Forestry experts, ILIAUNI, and in close cooperation with UNDP, MENRP, National Forestry Agency, Local information centers of the ministry of Agriculture MoA local Municipalities and population, relevant NGO's and were divided in three following phases:

Phase 1 – Analysis and site selection phase

Phase 2 – Field work

Phase 3 – Field data processing and reporting.

2. Main conclusions and recommendations

The survey results pertaining to availability of biomass residues for production of advanced solid biofuels can be shortly summarized as follows:

1. The field study confirmed that residues of annual crops are widely used for farming and animal feed and in general are not available for development of advanced biofuel production.

2. There is a significant potential of waste from perennial crops. The available volume of residues per unit area exceeds the estimates of previous desk study

3. There is a large accumulation and significant annual addition of sawdust in various regions where this sawdust can be used for production of advanced solid fuels. Sachkhere, Mestia and Adigeni should be considered the highest priority in this respect.

4. The highest identified available waste potential is with winery operations:

    a. There is a vast amount of vine cuttings available every year from the vineyards in Georgia that are simply burned without any use;
    b. There is a huge amount of grape pomace accumulated in big wine factories that is waiting for proper recycling and utilization
    c. It is advisable to conduct a more detailed assessment of usability of winery residues for producing the advanced biofuel

5. There are various attempts of producing alternative fuels or other products from plant biomass waste, however due to undeveloped market, low quality equipment and lack of support such attempts are not successful up to now.

3. Study objectives and methodology

1. Field study of the available amount of biomass on the territory of Georgia for its energy use

The objectives of the assignment was to verify the findings of the previous study by: justifying the results of desk study, examining the current usage of biomass residues, assessing the potential and costs for collection, assessing the conditions and identifying the barriers for commercial development of residual biomass as energy source.

The tasks of the study included:

- Verify the amounts of residual biomass in place and its conditions
- Identify the current practice of waste biomass utilization and disposal
- Assess the potential for biomass waste collection and estimate related costs

The study did not cover the whole territory of the country but mostly concentrated in typical locations and locations with expected higher abundance and higher variety of waste biomass.

The categories of biomass examined included:

1. Sawdust accumulated and potentially available annually from sawmills in different parts of Georgia
2. Biomass in forests including
    a. Residues from forestry operations of long term licensees
    b. Residues from social and illegal cuttings
    c. Available biomass from future early tending and trimming operations
    d. Biomass from fires, wind felling etc.
3. Agriculture residues from
    a. Vineyards and fruit orchards
    b. Annual crops, including corn, wheat, barley and others.

The following specific activities were conducted for each category:

1. The locations with potential highest concentration of the waste biomass were selected and the field visits planned,
2. The field visits were conducted, information was collected through inquiries and own assessment and was documented,
3. The data were mapped, analyzed and the results incorporated in this report

2. Development of GIS database for the available biomass

One of the main components of field survey of Potential for Biomass Use for Energy in Georgia was targeting Sawmills operation all over the Georgia. The questionnaire survey was conducted to study available residue resources, potential annual accumulation and, accessibility and other related parameters. Taking into account that spatial distribution of sawmills, respective wood resources, accessibility, etc, would play a significant role – GIS was selected as tool for data collection, visualization and analysis.

3. Remote Sensing as a tool for the residual biomass assessment in Georgian Forests - First approach study

An attempt was made to use the satellite imagery for assessment of the forest conditions and respectively the approximate amount of residual biomass in the forests. The idea is to use the multispectral satellite images calibrate to the visited forest site conditions and identify the extent of similar territories which might be an indication of the spread of e.g. residual biomass from illegal cutting In case of success, such a

method will allow to monitor the conditions of the forests and identify the high concentrations of residual biomass or the candidates for early tending or sanitary cutting.

4. Biomass Website Development

An important objective of the study was to develop a web platform for biomass promotion. Design the website with the account of best international practice and populate it with Georgian material for biomass use promotion. The website shall be used as a platform for cooperation and promotion of different organizations working on renewable energy from biomass.

Initial intention was to use WEG website expansion for such a platform however later it was decided to establish a separate website and to promote it through the WEG website and Facebook as well as websites and Facebook accounts of partner organizations.

4. Sawmill Survey

Phase I was used to obtain more detailed information from Environmental Supervision Department and National Forestry Agency concerning operating sawmills. Based on analysis of the received information the priority regions were selected for further field works.

Special equipment for wood moisture measurements was selected and purchased. The portable digital moisture tst meters selected were: Sonin 50270 Digital Moisture Test Meter and Extech MO210 Pocket Size Moisture Meter.

Based on agreed measurement methodology for the assessment of sawdust and woody biomass moisture content, the group orientation and training was conducted. At the same phase the project team developed a questionnaire for the survey of sawmills. The first visits were conducted in Khashuri municipality to test the methodology and equipment. The questionnaire was amended for the future work (see annex 1). In the process and after the field visits the quality assurance checks were conducted through telephone verification with the interviewees.

4.1. Identification of sawmills to be surveyed

For survey purposes more than 120 sawmills with the annual timber processing volumes in excess of 100m^3 were preliminary enquired, and finally 69 sawmills, currently operating in six regions of Georgia were selected. Following criteria for the selection of sawmills were used:

- Location in preliminary selected districts
- Yeas of operation
- Total volume processed in last two years
- No or minor management practice of sawdust and wood residues

- Availability of contact persons for survey
- Functioning status (operating/not operating).

The selected sawmills are distributed in Following regions:

- Samegrelo-zemo Svaneti – 23 sawmills
- Imereti - 17 sawmills
- Sida KarTli – 5 sawmills
- Kakheti – 6 sawmills
- Samtskhe-Javakheti – 8 sawmills
- Racha-Leckhumi Qvemo Svaneti – 11 sawmills

4.2. Sawmill Survey Process

The project team developed and tested the questionnaire for surveys of sawmills. The first visits were conducted in Khashuri municipality to test the methodology and equipment. The questionnaire was amended for the future work (see annex 1).

The procedure of sawmill survey included:

- Call to agree the visit
- On site inquiry and filling of the questionnaire
- Taking the photos of sawdust accumulation and machinery of the sawmill
- Taking the exact GIS coordinate of the sawmill and of sawdust accumulation
- Testing the moisture content of the accumulated sawdust
- Volume assessment of the accumulated sawdust
- Assessment of the access road to the sawmill

In the process and after the field visits the quality assurance checks were conducted through telephone verification with the interviewees.

Pic. 1 - Members of the survey team measuring the volume of accumulated sawdust

Pic 2. – Measuring the moisture content of the sawdust

The questionnaire was designed to collect the following information:

General information

1. Sawmill location (region, district, address, GIS references, owner)
2. Contact person interviewed (name, position)
3. Date of establishment
4. Basic machinery type
5. Number of employees
6. Volume of timber processed annually, among of which share of coniferous and broadleaves species
7. Plan for future operation of sawmill based on: Existing contract/contracts and Private orders

Specific information

1. Volume of sawdust and other sawmill residues left after primary processing of 1 m^3 round wood in percent each:
   - Slabs, edgings and off-cuts
   - Sawdust and fines
   - Bark
   - Various losses
2. Volume of sawdust and other sawmill residues left after secondary processing of 1 m^3 wood in percent each:
   - Sawdust and fines
   - Various losses
3. Total volume of sawdust and other sawmill residues accumulated per year
4. Total volume of sawdust and other sawmill residues accumulated during previous years

Assessment of sawdust and other residues

1. Disposal of the waste:
   - Inside of sawmill territory, description of disposal place and its size

- Outside of sawmill territory, description the disposal place (distance from sawmill, accessibility)

2. Condition of waste by categories:

   Fresh/wet – Dry - Rotten

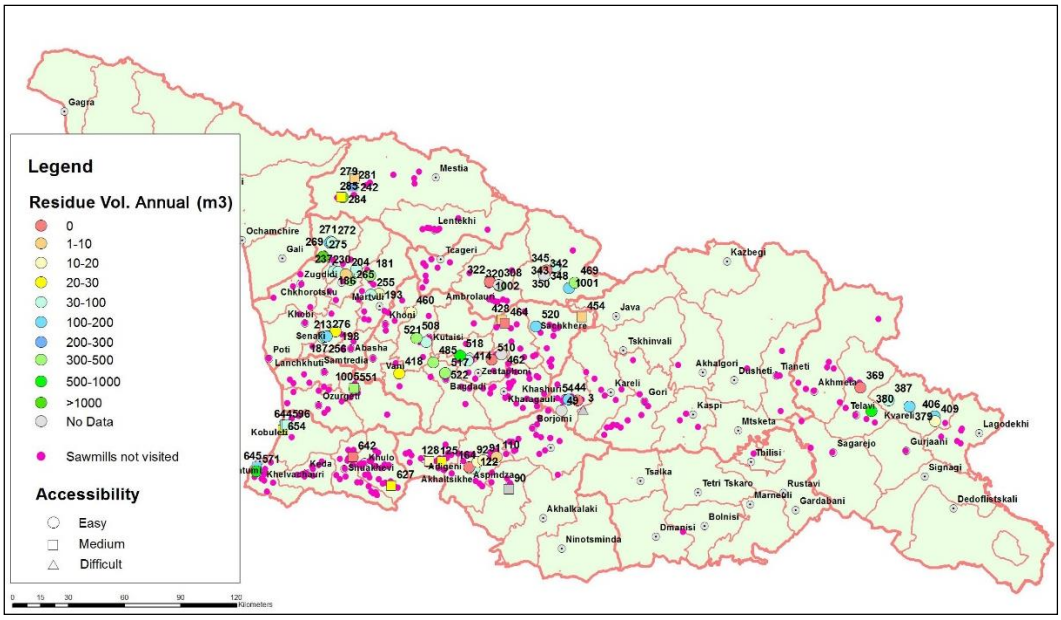
3. Approximate volume/weight accumulated at the moment of interview
4. How often sawmill management conducts measures to clean the sawmill territory from the waste and how much wastes are taken away
5. Are they any other users and approximate volume they take
6. Will the sawmill management agree to use of sawdust and other sawmill residues by other users and based on which condition:

- Free of Charge
- Payment fee (x GEL per one tone/m^3).

Locations of surveyed sawmills is provided in the picture 3 below. The map indicates the locations of all sawmills registered in the list Environmental Supervision Department. The sawmills visited by the project team are depicted in different colors, in accordance to the annual volume of available sawdust. The road conditions and accessibility of the visited sawmills is expressed by geometric shapes categorizing the level of accessibility as Easy, Medium or Hard.

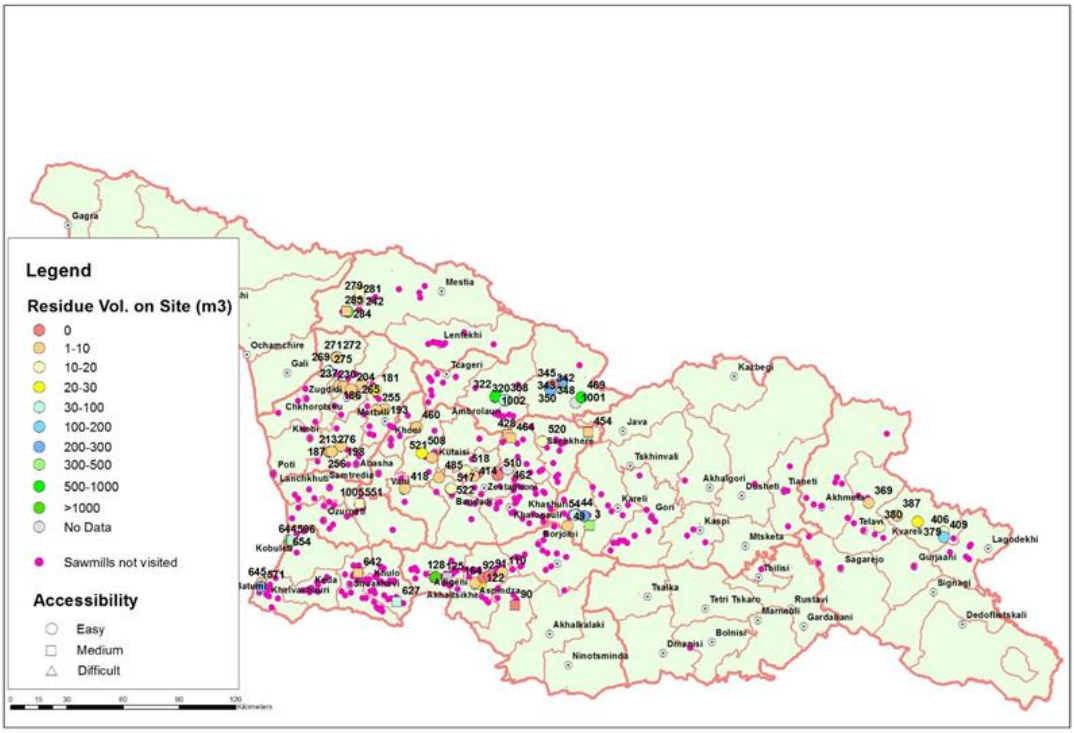
4.3. Results of sawdust survey

The main results of the sawmill survey are summarized in the picture 3 below. It indicates the location and amounts of annual volumes of sawdust as well as accessibility of the sites.



Pic.3 Results of sawdust availability survey annual potential of sawdust

The map below shows the amounts of residue observed on site in sawmills visited



Pic.4 Results of sawdust availability sawdust on site

A more detailed information about the exact locations and available sawdust amounts can be found on interactive maps at the website www.biomass.ge

4.4. Survey Findings

The Results of survey are summarized in the intermediate reports for each region. Detailed results are provided in the summary table of Annex 2

The following main findings are derived based on sawmills' survey:

Amount and condition of sawdust and other wood residues

Total amount of sawdust and other wood residues at the territories of interviewed sawmills is estimated around 32 thousand m^3. In many cases it is difficult to distinguish them by hardwood and coniferous due to all them are mixed in disposal area. About 25% of total amount is sawdust and fines and rest (75%) is consisting of slabs, edgings, off-cuts and bark. More than 90% of waste is in condition appropriate for further use.

The highest accumulation of sawdust was found in Adigeni Sachkhere and Kutaisi, where the amount of sadust exceeds several thousand cubic meters. The sawdust is being accumulated for decades and is partly deteriorated. High concentrations and high volumes of sawdust are available in Svaneti Mestia region however the remote location and lack of transparency in sawmill operations leaves it less attractive for outside investors.

Moisture content of accumulated sawdust

The sawdust accumulated in place in most of the cases has high moisture content. The measurements conducted by the survey team can only provide an indicative range of sawdust moisture since the measurements were taken by two different moisture testers in non-standard conditions and were not conducted in the laboratory. The general conclusion is that the sawdust of substantial thickness preserves the high moisture content in the range of 40% even after several months on the open air.

Basic machinery type

Machinery used in sawmills are mainly very simple and old (see photo gallery in annex), only a few factories are equipped with more advanced technique, these are sawmills owned by long term (20 year) timber use license holders (sawmills #284, 275, 265, 181, 517) and companies, which perform special infrastructure development programs (sawmill 1-005-0000548 in Sachkhere) and dealing with timber processing due to mining operations (sawmill 1-005-0000549 of the "Georgian Manganese" company in Chiatura).

Wood supply system

It is evident that most of sawmills suffer from the shortage of raw material which causes their unstable operation. Seasonal interruption in round wood supply is due to seasonal inaccessibility of the forests where this wood is being harvested.

Survey identified following sources of wood supply:

- **Timber use licenses**. The best option for stable and scheduled wood supply is the option when sawmill owners hold at the same time long term timber use licenses.

- **Special Governmental Resolution for the implementation infrastructural projects**. There is a big sawmill in Sachkhere (1-005-0000548) which implements social infrastructure development project and harvests and process around 5000 m^3 of coniferous wood annually.
- **Licensees for the extraction of mineral resources**. Company "Georgian Manganese" is processing wood imported from Ukraine for further use in mines.
- **Private land owners providing wood for processing cut at their private lands**. In many districts, in particular in West Georgia, rural population is cutting trees at their private lands (walnut, criptomeria, alder, cedrus) and uses services of small sawmills for the processing.
- **Purchase of wood from long term timber use license holders.** Some sawmills , which own wood harvesting machinery are involved on contractual basis in timber harvesting operations by license holders and purchase from them the wood of quality not satisfactory for license holders.
- **Illegal source.** Most likely sawmills are involved in processing of illegal wood as well, though it is beyond of project team competence to deal with illegal sources.

Legal Environment

The legal environment has to be improved in order to be more supportive for utilization of forestry residues. Decree of the Government of Georgia #46, January 10, 2014 "On the movement of round wood and Technical Regulation for the operation of sawmills on the territory of Georgia", article 14 identifies the following basic requirements (see box 1) for the management of sawdust and other wood residues after primary wood processing:

Box 1.

Article 14. General Conditions

1. *Sawmills should satisfy requirements identified by this article;*
2. *Installation and dismantling, also disposal of wastes after wood processing is prohibited:*
   - *At the territory of State Forest Fund,*
   - *At the territories of Protected Areas,*
   - *Along the river bed, ravine or main irrigation canal from the ends of both sides - within 50 meters,*
   - *At the water protection zones of the lakes and water reservoirs*
   - *At the area of Black Sea coast.*

Wastes raised after primary wood processing should be allocated in at least 1, 5 m high special concrete bunker.

Violation of above mentioned requirements is subject to fines and penalties up to 2000 GEL identified by Administrative Violation Code of Georgia, article 128^3, p.3.

Many of sawmills confirmed that they were fined by Environmental Supervision Department for the violation of required legal conditions related to disposal of wastes, though there are also fines concerning of violation of the requirements of new regulation "Inventory report on the pollution of the atmospheric air", which caused fines to several sawmills in West Georgia in amount of 500 GEL.

Management of sawdust and other wood residues

Management of waste products at sawmills is an important problem that sawmill administration/owners would like to solve. According to survey results there are different approaches currently used by sawmills:

- Burning at the territory -5%
- Disposal at the sawmill territory for further decay – 5%
- Transfer to local population (free of charge) -6%
- Selling to local population – 3%
- Disposal out of the sawmill territory – 12%
- Disposal at the special landfill – 30%
- Use by sawmill for heating and drying of their wood products – 31%
- Further processing for briquettes – 8% (there are many simple factories producing briquettes established in different regions, see photo below: briquette producing factory in Akhmeta):

Pic.4. Bricket producing shop

There are several cases when the sawdust is being used for production of briquettes or pellets:

- Kula company is collecting waste from the Gverdzineti (Kareli) sawmill #3
- In Akhmeta there is a small briquette factory which however has the problems due to poor quality of equipment
- In Khaishi (Svaneti) the sawmill has started briquette production, however the chinese production machine is not suitable to the fine sawdust, therefore the owners are trying to adjust the equipment to local condition by replacing some parts

In most cases the operation is not successful either due to poor equipment or marketing.

Owners of sawmills, holding also long term licenses, as well as other sawmills involved in timber harvesting confirmed that about 50% of total volume of wood harvested is left in forest and they will support removal and utilization of residues. Namely some of them expressed readiness to explore the possibility of chipping the remaining big branches and evacuating from the forest by tucks.

Establishment of mechanisms for wood waste collection and transportation from sawmills may significantly increase its amount since sawmills will stop the practice of burning and disposal of sawdust and other wood residues.

4.5. Conclusions

The main findings of sawmill survey are as follows:

- About 16 000 m^3 of sawdust and wood residues are accumulated on the territories of sawmills surveyed.
- Operation of sawmills are not always transparent. In some occasions, the annual amounts of sawdust quoted in the interviews as well as accumulated amount in place indicate towards a higher volume of wood processing than officially reported.
- Taking into account that there are around 600 officially registered sawmills not surveyed, also high number of illegally cut and processed wood, final amount of available sawdust and other wood residues seems to be considerably higher.
- The operation of sawmills is highly seasonal, due to poor access to the forests in late autumn-early spring and even early summer periods.
- Waste disposal poses problems to sawmill owners and many of them have been fined. Most of sawmills agree to clean-up their territories from waste and may be ready to provide it free of charge to interested parties
- Demand on sawdust and other wood residues from local population is increasing, in particular in the regions with shortage of firewood supply like Kakheti and Samtskhe-Javakheti
- The use of new technologies for production of modern solid biofuels from sawmill waste by local entrepreneurs is gradually increasing.
- It is recommended to promote the production of advanced biomass fuels with the existing sawdust owners/operators, in order to avoid the additional link in supply chain.

5. Waste Biomass from Forestry

5.1. Selection of forests for field work

Phase I of the project was used by the project team to obtain the detailed information from relevant state institutions (Central and local offices of the Environmental Supervision Department and National Forestry Agency) on wood residues accumulated in the forests and on the locations where alternative woody biomass might become available from early tending & thinning and the measures in support of natural regeneration. Based on analysis of the received information the priority regions were selected for further field works.

Selection of forest sites was done in cooperation with NFA and sawmill owners, who offered their support to show places of high concentration of wood waste. In late winter and early spring – when the study was scheduled, the accessibility of project team to the forest was significantly limited due to difficult weather and road conditions (see photos).

Pic.5,6 – Poor road conditions in the spring

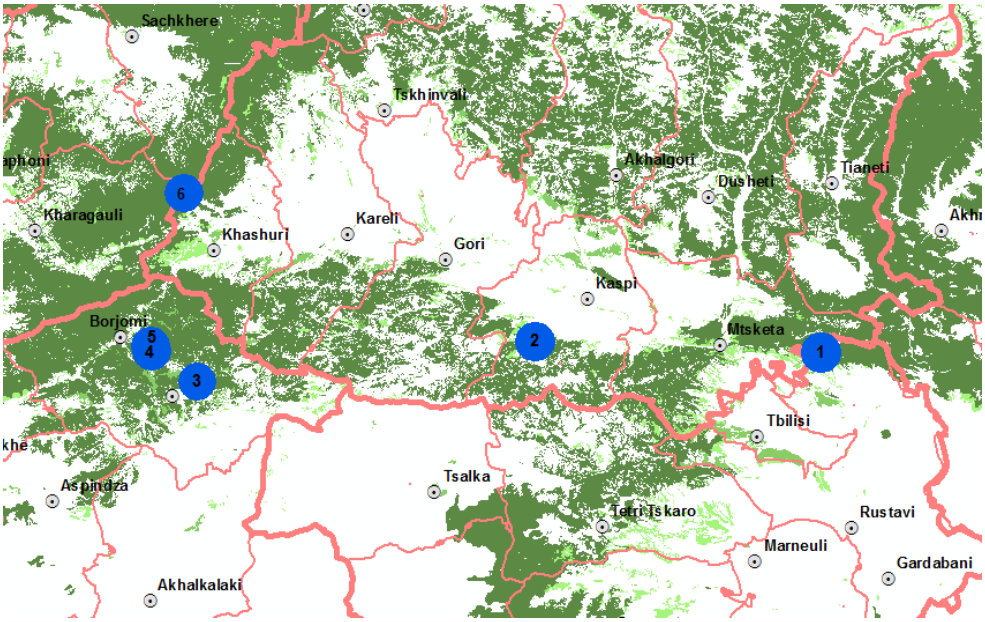
In site selection the diversity of potential sources and origins of expected wood waste was reflected, in particular this included:

- Wood residues after legal timber harvesting operations conducted by license holders or local population
- Wood waste after illegal timber harvesting
- Wood originated due to natural events (windfall, pest and diseases, fires, etc.)
- Potential sites of early&mid-term tending and thinning and other forestry measures

Based on above mentioned approach following forest sites were selected for field assessment:

1. Kvemo Kartli region – Martkopi forest unit. The broadleaved forests composed from oak and hornbeam suggested for assessment by NFA, wood waste is originated from illegal cut in 2011-2012 by local population.
2. Sida Kartli region – Khashuri forest unit. Place was selected by advise of sawmill owner in Khashuri, also involved in timber harvesting. Wood waste origin is timber harvesting by license holder.
3. Samtskhe-Javakheti region – Borjomi-Bakuriani forest unit. The area selected by local NFA staff presents combination of broad leaved and coniferous forests with wood waste after illegal cut and trees felled by wind.
4. Samtskhe-Javakheti region – Borjomi-Bakuriani forest unit. Big territory (900 ha) burned after armed conflict in 2008 with plenty of trees left.
5. Sida Kartli region – Khashuri forest unit. Surami Forest unit with high coverage of evergreen bushes.

Location of forest sites selected is provided in the Picture 7 below:



Pic. 7. Map of location of selected forest sites

5.2. Survey process

For the field assessment of wood residues in forests it was decided to use aerial photography already being in applied in Ilia State University for Geology and Biodiversity applications. Methodology included estimating the quantity of bio-degradable Material (Biomass) in the forest through Photogrammetric Method. Method selected is based on aerial photo shooting from a drone. For this task UAV (Quadcopter Dji Vision Phantom 2) and a remotely operated camera (Nikon Coolpix AW 110) adapted to android system were used.

Photos taken from the aerial camera include geographic coordinates (longitude, latitude) and also elevation. Data was processed in a special software package (AgiSoft PhotoScan Pro 1.1.4). The program enables to perform the whole processing cycle of photogrammetric shooting. On the first stage, photos were selected based on the quality of images, points were georeferenced and photos were matched to each other to create a complete synthetic image of the whole area.

Final product from AgiSoft PhotoScan Pro 1.1.4 is a geometrically correct image on which it is possible to measure any object of interest (a log, a tree trunk, a leaf etc.). In order to make necessary measurements GIS (ESRI; ArcGis 10.2.2.), namely ArcMap software was used. Georeferenced Aerial photo was exported to GIS and following activities were performed:

1 – Identification of residual biomass on a given orthophoto and measuring its size (diameter and length). Measuring was done using a special “measure” function and measured data was storred in the corresponding fields of attribute table.

2 – For each piece of wood an approximate distance to nearest road or possible access was also measured and recorded in the table.

3 – Estimating overall volume of residual biomass from measured sizes, calculations were performed within attribute table, using simple functions.

In comparison with visual assumption mainly practiced by foresters the mentioned methodological approach significantly reduces field group task avoiding extra walk of field group on the target territory and makes measurement very transparent and accurate due to calculating volumes of each log. The images can be used for later reference and assessment of any changes in the forest.

Pic. 8,9 waste wood after illegal cuttings, quality of wood in place

The procedure also included assessment of the quality of the remaining wood residues by cutting the samples on a scale of good/marginally useful/deteriorated; The measurements of moisture content were also conducted however it became clear that the wood residues were found to be air-dry.

Field works were conducted by project team consisting of project forestry expert, Ilia State University personnel dealing with testing of quad copters and NFA Central and Local Office staff. High level (Minister) personnel of the Ministry of Environment and Natural Resources Protection were also informed.

During the field work project team made visual assessment of alongside forests, focusing on the needs of early&mid-term tending and thinning and distribution of evergreen bushes as potential alternative woody biomass.

Pic.10. Manual measurements of residual wood

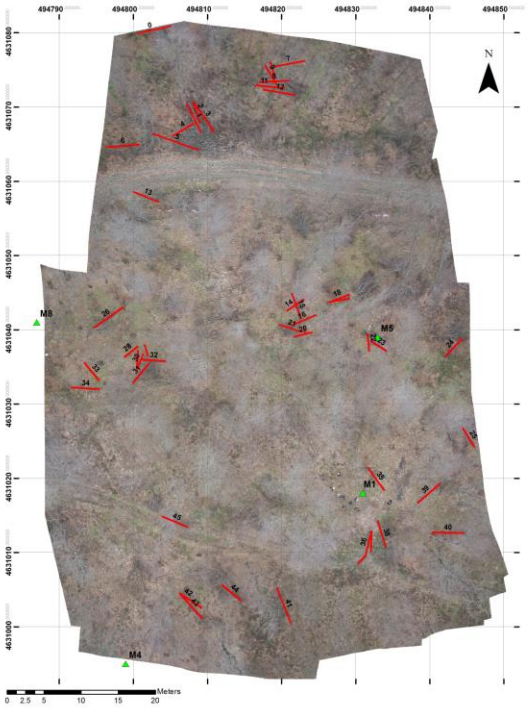
The measurements with traditional methods were also conducted in order to compare the results with the same measurements conducted through aerial photography.

5.3. Results of the field work

Qvemo Kartli region – Martkopi forest unit

Forest site is located near Tbilisi at v. Martkopi. Total area affected by illegal cut in 2011-2012 is 196 ha which presents one compartment of Martkopi forest. It was a first test of new quadcopter technology and for the comparison of the measurements some logs were also measured manually at the ground and marked for the visibility after shooting by camera. The overall picture of the studied territory is given below:

Picture 11. Forest site Martkopi Area 0.4 ha Total Volume= 1, 85 m^3



The picture can be zoomed in for examination of details. The forest roads and paths are visible. Red line segments show the location of small tree trunks in place. The small dots on the low right of the picture is the field team together with representatives of the local forestry office.

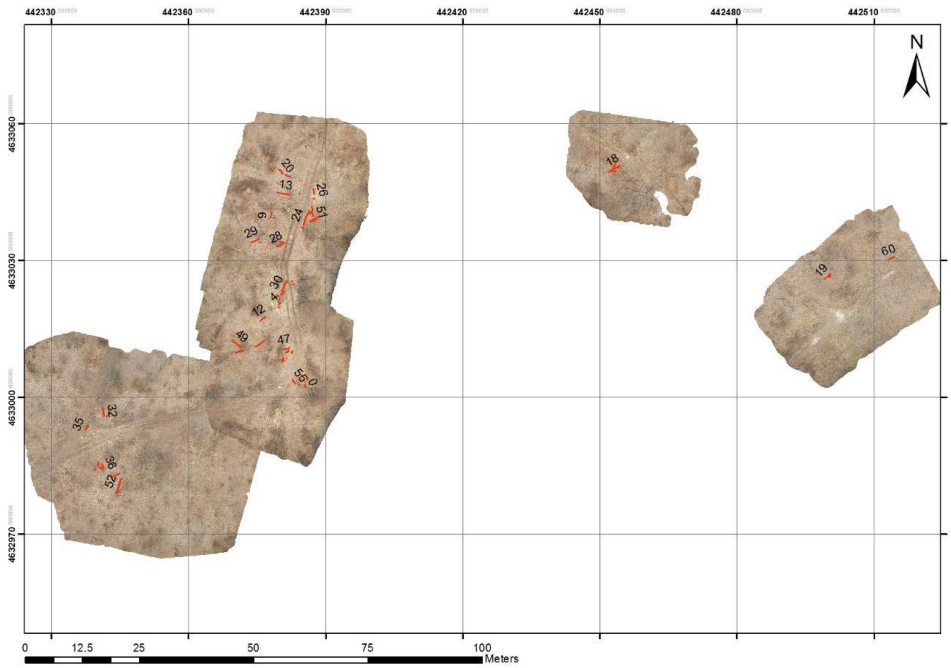
The log sizes for sample logs calculated manually were close calculated by software within the accuracy of 5-10% which was considered to be sufficient for such measurements.

Based on the selected forest area, the average density of wood residue in the forest was estimated and extrapolated for the whole compartment (196 ha) using the information from the local forestry representatives and amounted as 800 m^3. Forest road is crossing whole compartment. Average distance for the collection of wood and bringing to the road is about 10 m.

Sida Kartli region – Khashuri forest unit

This area was chosen to examine the residues left after licensee operations. The area was allocated under long term timber harvesting license. It is crossed by road constructed for the harvesting purposes by license holder. Below is the aerial photo of the investigated area.

Picture 12. Forest site in Ertatsminda - License Territory Area : 0.46 Ha Residue vol: 1.03 M3

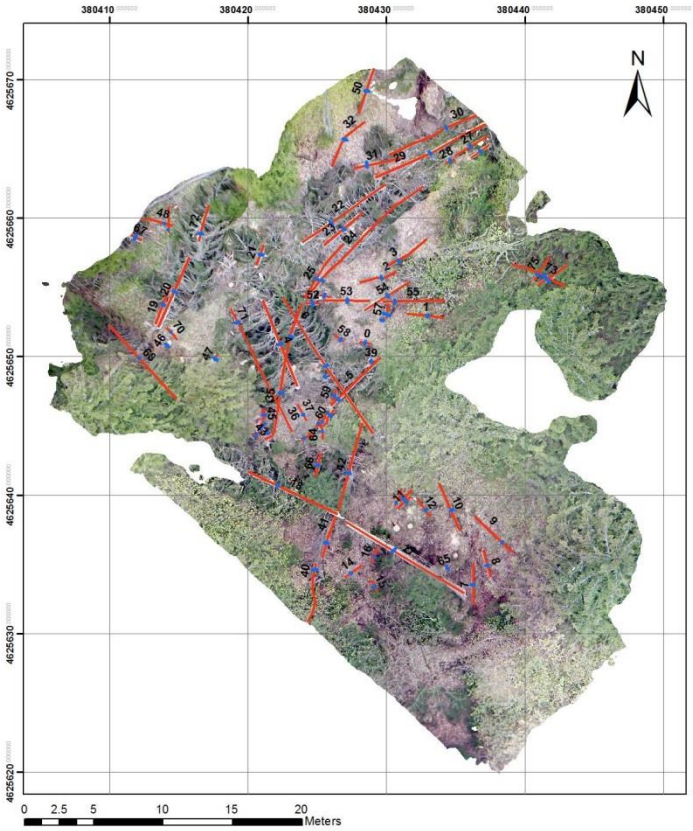


1.03 m^3 of wood waste were detected at 0, 46 ha, which is lower than the density of residues from illegal cutting. Total license area allocated for timber harvesting is 5681 ha of which at least 30% is affected by felling operations. Therefore, it is assumed that about 3400 m^3 of wood waste is left in that forest.

Samtskhe-Javakheti region – Borjomi-Bakuriani forest unit

This area was selected because of double origin of wood waste assessed. This includes illegal cut and natural event (windbreaks).

Picture 12. Forest site in Mitarbi - Illegal cut and windbreak Area 0.14 Ha Residue Vol. 8.3 M3



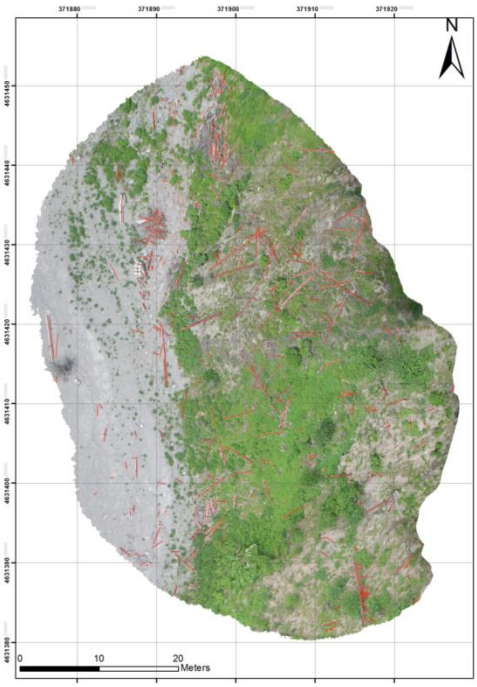
There is a considerable high volume – 8,3 m^3 at relatively small area (0,14 ha). Distance to the closest road is about 100 m.

Borjomi – Village Daba

Coniferous forest site in Borjomi at v.Daba was selected to examine the amount of remaining biomass after forest fires from the war of 2008. Total area burned is around 900 ha. Assessment of wood waste was done in two places which identified 6,7 m^3 at 0,27 ha and 67.08 m^3 at 1,1 ha. Since there are already seven years passed after accident, wood quality is low - mostly dry or deteriorated.

Picture 13. Forest Site – Borjomi, v. Daba 1 Borjomi – Village Daba

Forest fire remains Area 0.27 Ha, Total Vol. = 6.7 m3


371880
371890
371900
371910
371920
4631460
4631440
4631420
4631420
4631410
4631400
4631390
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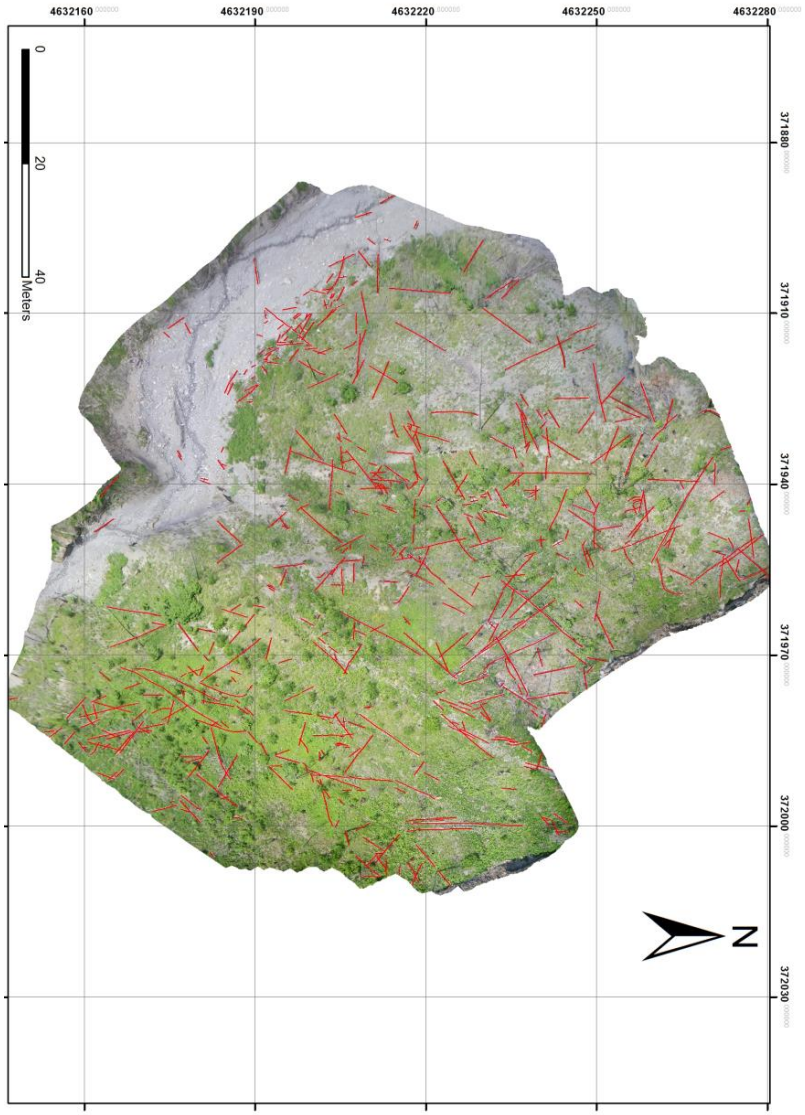
N
0
10
20
Meters

Picture 14. Forest Site – Borjomi, v. Daba 2

Area 1.1 Ha, Tot Vol. = 67 .08 m3



Assessment of alternative woody biomass potential

Need for early & Mid-term tending and thinning is evident, there are plenty of areas of young and middle aged high density forests requiring relevant silvicultural measures (see photo). At the same time it is evident that open areas in broadleaved forests observed (in particular khashuri forest site) are densely covered by *Rhododendron* species. All this may provide significant amount of alternative woody biomass. To make somehow precise assessment of such potential data from latest inventory (2014) of Kharagauli district forests was obtained and analyzed. According to this data almost half of the forest territory of this district – 25 Thousand hectares – is totally covered by *Rhododendron*, which is equal to about 250 Thousand m^3 of woody biomass.

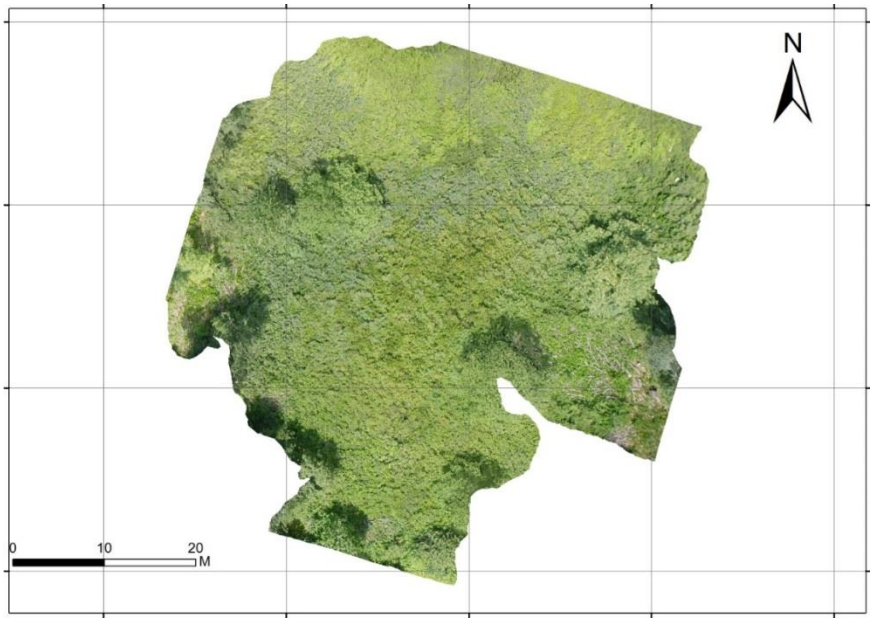
Picture 15. Young forest – candidate for thinning

Sida Kartli region – Khashuri forest unit

Site was selected to assess the distribution of evergreen underbrush that needs to be removed in order to allow the growth of forest area.

Picture 16. Forest site

Surami – Underbrsush to be removed Area – 0,23 ha Covered by *Rhododendron* – 83%



The result of assessment is that more than 80% of the searched territory is covered by *Rhododendron*. There is no updated forest inventory data for this section of forests. According to verbal information of local foresters more than 5000 ha is in the same condition as it was identified in selected site. After cleaning of these forests approximately 50 000 m^3 of wood biomass might be generated (it is estimated that one hectare gives around 10-15 m^3 wood).

Legal environment

Georgian legislation provides different requirements according to sources of origin for the use of wood waste in forest:

- Wood waste from timber harvesting by license holders can be collected with the consent of license holders. Since the stumpage fee for the harvesting of whole tree is already paid by license

holder, no other official taxes for the use of natural resources need to be paid. The costs envisaged are related to handling and transportation.

- Wood waste arising after timber harvesting by local population (industrial wood and fire wood) also wood waste after natural thinning due to wind break, fires and diseases belongs to NFA and they are allowed to provide them to local population for social needs. Wood waste with less than 12 sm diameter can be collected without official permit free of charge, above 12 sm needs to be officially accounted before allocation for use. Same tax as for fire wood (around 3 GEL per m^3) to be paid by user.
- Wood waste from illegal cuts is not allowed to be collected until investigation is completed and the waste officially becomes state property under Agency of financial services at the Ministry of Finances, which is dealing with all confiscated goods and products in Georgia for further subsequent selling through auction. This is very confusing system since the investigation process may last several years (e.g. Martkopi case) and wood wastes may significantly deteriorate.

5.4. Costs of collecting sawdust and waste wood from forests

Costs of collection of sawdust and other wood residues at sawmills to be relatively cheap and can be estimated by the distance from main roads and the road conditions as indicated on the map Pic.1. The cost of loading the sawdust is insignificant and can be estimated as 10-20 GEL per truck.

The cost of collecting the wood waste from forests is significantly higher The estimated cost of hiring the local trucks e.g. in Khashuri area for the 10-15km forest roads at off-season is about 300-400GEL which makes collection of waste biomass even in late spring-early summer questionable. The fuel economy of KRAZ trucks used in the forests is about 45-50 lit/per 100km. Even if doubled due to poor road conditions this translates into 40-50 GEL for fuel per a trip to-from forest site at 10km distance. With own truck such a trip could cost around 100-150 GEL

The NFA is considering improvements of road infrastructure in the forests. The estimated cost for arranging the new forest roads is about 11 thosand GEL for one kilometer of the new road, while the repairs can be much cheaper and amount to 3-4 thousand GEL for the kilometer of road repair/restoration

The efficiency of wood residue collection from the forests may be increased by having a mobile team consisting of high capacity chipper and the trucks with high board trucks to transport the ready material from forests. This option was favorably discussed with the license/sawmill owners in various regions.

5.5. Main findings of Forest Survey

Wood residues in forests:

- The amount of wood waste accumulated in Georgian forests, in the areas of illegal cut is estimated at around 4.5-5m^3 per hectare.
- All wood wastes originated after timber harvesting are distributed in the vicinity of existing or former forest roads, though they need to be repaired (cleaning and leveling) prior to use.
- In most cases this wood is kept by the prosecutor's office as physical evidence and is not allowed for utilization otherwise the local population would take most of it.
- Collection of wood waste from forests is quite expensive and depends on the conditions of the road and distance to the wood felling area.

- The results of previous desk study9 and the field survey suggest the **Samegrelo-Zemo Svaneti, and Imereti** as priority regions with higher potential of wood biomass:
    - Annual timber harvesting (industrial and fuelwood) in Samegrelo Zemo Svaneti is equal to 158 thousand m^3 which will accumulate about 56 thousand of wood waste, and in Imereti 176,6 Thousand m^3 accumulating 62 Thousand m^3;
    - Number of sawmills operating in regions. 112 sawmils are operating in Samegrelo Zemo Svaneti and 118 in Imereti.
    - Annual sawdust volume accumulated at sawmills. 35 444 m^3 is sawdust potential in Samegrelo Zemo Svaneti and 23 943 m^3 in Imereti.

Use of Aerial photography

The developed method for wood waste assessment in the field proved to be effective, it saves time, provides accurate measurement, identifies georeferenced location of the territory and each piece of wood in it, and easily calculates distances of the target area and each log from the main road which may ensure better planning of removal operations.

It is common understanding of project team and professional foresters that such modern equipment can be effectively used for other purposes, such as:

- Physical control of the forest
- Forest fire control through the identification of fire places at very early stage
- Forest pest and disease control, in particular visual observation of the signs of disease at the level of tree crown
- Forest inventory at the small forest unit level.

It has additional side benefits of better forest monitoring control and cost reduction. It can ensure accurate calculation of timber volume left in forest, as well as provide the valuable data for proper planning of removal activities

Limitations – can be used mostly in broad leaved forests in autumn winter period. Heavy duty off-road cars need to be used for the forest team since in this period the forest access roads are very muddy and hardly passable.

Recommendations

- Existing legal framework needs to be revised with aim to allow business companies to collect wood wastes[10]

9 "Assessment Of Wood And Agricultural Residue Biomass Energy Potential In Georgia", WEG, 2014 http://weg.ge/wp-content/uploads/2012/01/FINAL.pdf

10 NFA has drafted changes in existing regulations to simplify and diversify the use of wood wastes.

- Planning and implementation of early & mid-term tending and thinning as well as measures to support natural regeneration can become an important source of alternative woody biomass. Special study is required to identify scale of such works and possible timber volume output
- In long term the accumulated sources of wood waste in sawmills will be exhausted due to increased internal use and demand from outside for further processing. Therefore, wood waste derived from forestry operations seems to be more sustainable source in long term.
- Selection and use of proper machinery in the forest may be economical and needs more detailed feasibility assessment.
- Companies involved in wood harvesting and processing are the priority target group for promoting the production of advanced solid bio fuels from sawdust and waste wood.

6. Agricultural Waste Survey

6.1. Site selection and Methodology for Field Studies

Preliminary study to assess the potential of existing wood and agricultural residue was conducted by World Experience for Georgia in 2014. Based on this study several regions have been identified for further research according to the following criteria:

1. Amount of residue – regions, with more residues were selected for further research. Both annual and already accumulated residues were considered in the process (for example, wine pruning residues from previous seasons are concentrated in fields in some regions).
2. Transportation – transportation issues were one of the main criteria, it's important that residues were technically available for businesses or other stakeholders.
3. Alternative use of residues - in some regions, there are considerable amount of residues, which have alternative use, for example, corn Stover is mostly used for animal feeding and bedding, therefore, potential of corn Stover energy use is low.

According to these criteria, the following field sites have been researched: 4 Regions (Shida Kartli, Kvemo Kartli, Samegrelo and Kakheti) 10 municipalities (Gori, Zugdidi, Abasha, Gurjaani, Sagarejo, Telavi, Kvareli, Akhmeta, Dedoflistskaro, Gardabani), 42 Villages (see Annex 4).

Different residues in different regions have been studied and analyzed.

PICTURE 17 - FIELD STUDY REGIONS FOR AGRICULTURE WASTE

Research methodology included quantitative research methods[11]. At the first stage following target groups have been identified:

- Farmers (owners of 2- 5 ha and 5- 18 ha lands)
- Regional Information-Consultation Centers of the Ministry of Agriculture
- Services of Amenities at municipalities
- Entrepreneurs

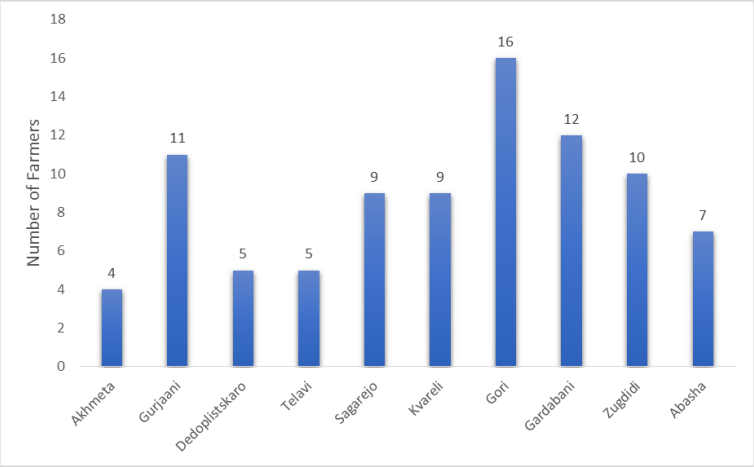
Questionnaires for all four groups have been elaborated considering differences within the groups.

Testing surveys with farmers have been conducted in Sagarejo and the telephone survey in Gori and Telavi. As the surveys showed Services of Amenities do not have any information on agricultural wastes. Survey with revised questionnaires (attachment 1) has been conducted with farmers and Regional Information-Consultation Centers of the Ministry of Agriculture, using).

Following methods have been used:

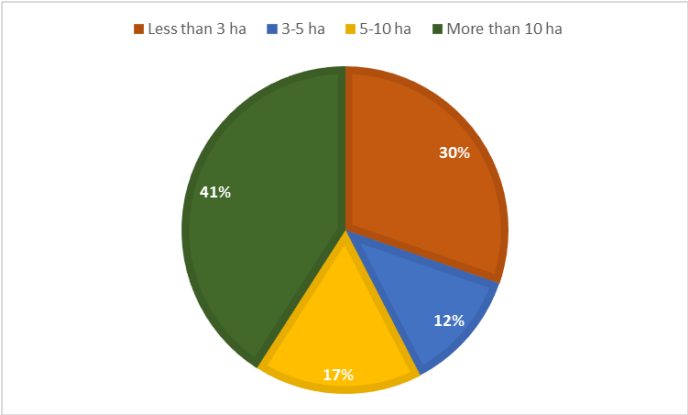
- Interviews by field teams
- Focus Group discussions organized with the help of
- telephone survey – mostly in relation with annual crops used for animal feed

11 „Survey Methodology" by Robert M. Groves (Author), Floyd J. Fowler Jr. (Author), Mick P. Couper (Author), James M. Lepkowski (Author), Eleanor Singer (Author), Roger Tourangeau (Author)- 2009



PICTURE 18 - NUMBER OF INTERVIEWED FARMERS ACCORDING TO MUNICIPALITIES

In total; 88 - Farmers 7 - Regional Information-Consultation Centers of the Ministry of Agriculture (Telavi, Kvareli, Gori, Sagarejo, Zugdidi, Gardabani, Dedoflistskaro) have been interviewed



PICTURE 19 - CATEGORIES OF INTERVIEWED FARMERS ACCORDING TO AREAS OF LAND

For calculation of residue amount, empirical data from field study is used.

6.2. Research Results

Research results are presented by the thematic components as followed:

- quantity of residue by different species
- Waste generation season and its features
- Waste disposal and use
- Expenditures connected to waste disposal

- knowledge and information about the alternative ways for using waste
- Readiness to cooperate with interested parties

Residues by Different Species

Vineyards

Cuttings from vineyards seem to be the most abundant residual biomass which does not have wide spread alternative use.

The i amount of pruning was hard to assess with the high confidence, since different farmers reported the waste amount in different measures, including number of bunches, number of cars per hectar, or weight per hectare. The most frequent answers converge to the amount of 3.2-3.5 tons of vine pruning available from 1 ha. 40 farmers were interviewed with the total farming territory of 195 hectares and 643 tons of waste.

The most common species of grape are “Rkawiteli” and “Saferavi”, Farmers point out that if the vineyard is intensive and planted with new species, it needs much less cutting and if it is old, the eradicated waste will be added to punning residues.

All interviewees confirm that they burn about 90% of vine cuttings immediately after removal from the vineyards.

Fruit prunings

About 15% of fruit orchards are “intensive” virus free where the cuttings are shredded and left in the fields. The remaining 85% are extensive orchards vulnerable to viruses and in these orchards all cuttings are removed and burned.

95% of Vine and fruit pruning is accumulated in spring and is taken away from the fields by the 15th of March. It is crucial because, leaving them causes disease and also hampers the agricultural work. The remaining 5% is for farmers whose work may be performed in fall.

3.5 tons of pruning residues are left from 1 ha fruit orchard. 25 farmers with 104.4 hectares fruit orchards were interviewed, 365 tons of waste is accumulated annually from the whole farming territory. Farmers mainly burn cuttings or consume for private use. Are willing to give the residues to third parties.

Hazelnut

Two hazelnut businesses and an informed representative of the state register were interviewed in Zugdidi. According to respondents: Approximately 50-60 thousand tons of hazelnut is produced in Georgia every year, main regions for hazelnut are Guria, Aphkazeti and Samegrelo. 80% of hazelnut is produced in Zugdidi, where 10 big and 50 small businesses are operating. 40-50% of total hazelnut amount is residue. People use this residue for heating and cooking, but respondents mention, that usage of hazelnut residue decreases gradually because of the gasification process in spite of the fact that gas heating costs 3-4 times

more (120 GEL worth of shells were sufficient for the heating season before). Because of the good prices, producers tend to increase their production.

According to the respondents, the hazelnut shells are stored on the open air and are often wet. The population prefers to use the wet shells for heating since they are burning longer.

The price for the hazelnut residues varies by season. In the beginning of the season the wet residues cost 5-7 tetri per kilogram while in the high season the price is 10-15 tetri locally. In 2014 some Turkish businessmen bought the residues for $50/ton

Bay-leaf

During the last 2-3 years bay leaf has a growing demand from regional and the international markets. Attractive prices provide incentives to farmers to revive bay leave growing and harvesting, while some private entrepreneurs have set up further processing. Due to favorable climatic and soil conditions this plant is mainly spread in the western regions of Georgia - Samegrelo, Guria and Imereti. Inquiry with the consultation center of the ministry of Agriculture indicated that Samegrelo is the major producing regions, and within the region, 70-80% of production is concentrated in Khobi municipality.

5 bigger bay leaf producers were interviewed in Khobi during the research and the results were similar. All of them mentioned, that 800-1000 kg residue is produced each day, (about 1000 tons annually in the interviewed businesses only). According to the respondents, after drying and separation 25-30 kg batches leave 5-6 kg of bay leaf and about 10-12 kg of residual fine branches. Unlike hazelnut shells, which are successfully used by local population, these small braches are inconvenient for direct use as a fuel for heating and are often burned irrespective to the ban by the law.

Picture 19 – Residual bay branches and the burning site

In general, bay leaf producers use the remaining dry fine branches for leaf drying. Most of them have special shredders where about 30% of residual dry fine branches are shredded for subsequent use as a fuel for drying the new batches. The remaining residue is being “secretly” burned which is banned by the law. Burning of shredded branches is inefficient in most cases and farmers have shown the remains

of incomplete burning. Therefore in case of efficient stoves the remaining unused can be even higher than current 70%. All respondents with dryers complain on incomplete burning even of the shredded remains.

PICTURE 20 – DRYING FURNACE AND DRYING ROOM

After the interviews with farmers, information about 20 businesses provided by local consultation centers were collected and analyzed. They produce 128 tons of bay leaves on average (about 2500-2600 tons of leaf in total), according to the above bay leaf-to-residue ratio this means 250-260 tons of residue out of which Estimated 70% -or about 170 tons is not used. Therefore the bigger 20 businesses in Khobi municipality produce about 3400 tons of residual biomass in the form of dry fine branches and its disposal creates problems for producers.

PICTURE 21 – SHREDDER AND THE PRODUCED FUEL

In summary: The actual bay leaf production figures are higher than estimated in the theoretical study. More than 3500 tons of residual biomass can be available from bay leaf production only in Khobi municipality although one of the businessmen has vaguely indicated potential plans of own use of the

production residues. If the burning efficiency of driers gets increased, this will leave even more residual biomass.

The residual biomass could be used as fuel for winter heating by population after shredding. However the appropriate stove design and its efficiency of burning needs to be addressed. As an alternative, the residual bay biomass could be used for producing advanced solid biofuels.

Annual Crops

Interviews were conducted with five RICCs in Kakheti (Telavi, Sighnaghi, Gurjaani, Sagarejo, Dedoplistskaro) as well as farmers

Farmers take 100-150 pressed stubbles and corn straw from 1 ha. One pressed unit weights approximately 20 kg. 2.6 tone of corn Stover is accumulated from 1 ha. Totally 1313 tons of residue is available annually from crops.

Generating process takes place in late summer and fall. Large amount of grain waste can be found in Kvemo Kartli and Samegrelo, where the corn harvest occurs in late summer and the waste is also collected during this period.

As for cereal crops, the difference between the varietal characteristics in terms of waste generation is insignificant.

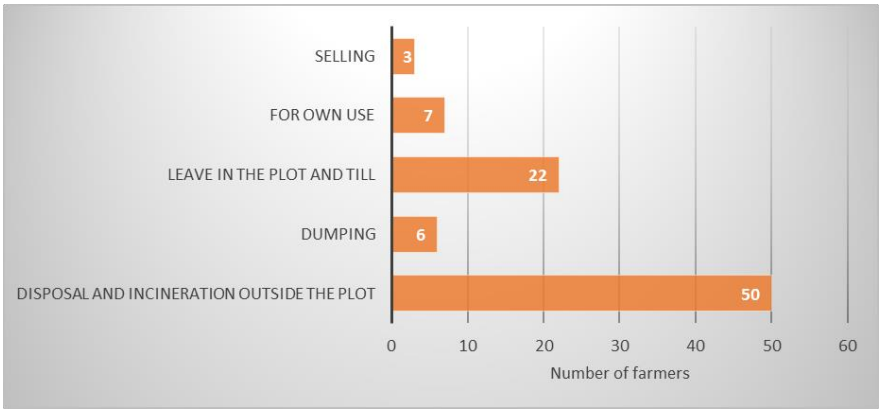
Corn straw - The inquiry was used mainly to determine the current use of corn residues. According to the inquiry about 2.6 tons of corn Stover is accumulated from 1 ha. Totally 1313 ton of residue is available annually from corn. However, this is fully used as animal feed and is not available for fuel production,.

Wheat straw – According to respondents the wheat straw is being used for animal feed and bedding it is not available for other uses. Only Dedoplistskaro RICC reported leaving about 50-60% of straw and burning it in fields. As a result the fires are deteriorating the soil and have caused the wind break fires.

Sunflower - Interviews with the four RICCs in Kakheti confirmed that the sunflower is harvested by special machinery that takes only the seeds and leaves the sunflower stems, roots and the heads of flower in the field. These residues are left in the field and ploughed into the ground next year. There is no consideration of using these residues in any alternative way. The amount of residue was hard to estimate from practical considerations. The amount of yield 4.5 – 6 t/ha crop residue and 1.5–2 t/ha seed yield from the theoretical study was roughly confirmed. The area under sunflower is much higher than in theoretical study and approximates 14000ha.

Waste disposal and use

Research has revealed that most of the waste is collected and burnt on the field by farmers. A relatively small part of waste is left on the fields and also is used for other purposes, more detailed information can be seen on the graph below:



PICTURE 20 –DEALING WITH RESIDUES

As for the straw, farmers mostly leave them on the ground or use for cattle. Only three farmers sold the residue and had been paid 0.40 tetri for bunch. 30-40% of straw is left on the ground. Rest of the residue is used for animal feeding.

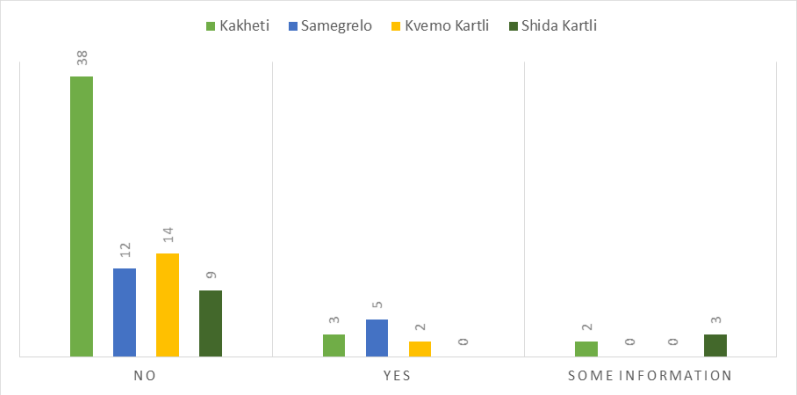
Expenditures for collection and disposal

Most of farmers say that they hire someone for different field work. Number of employees hired during the season are 5-10 people. Approximately 400-600 GEL is annual expenditure waste disposal, for bigger farms, this amount increases up to 1000 GEL. Expenditure on waste disposal varies across the residue types.

	Expenditure on resume disposal per hectare (GEL/ha)
Vineyard residue	40 GEL/ha
Fruit trees residue	62 GEL/ha
Straw	11 GEL/ha

Knowledge and information about the alternative ways for using waste

There is lack of information about residue alternative use. 80% of respondents do not have any information about possible ways of waste recycling.



PICTURE 21 – DO YOU HAVE ANY INFORMATION ABOUT RESIDUE ALTERNATIVE USE?

Readiness to cooperate with interested parties

100% of the respondents say that they would be interested and would cooperate with other stakeholders about taking away the residue. Most of them are willing to give up the residue for free.

Waste from Winery operations

According to GEOSTAT, more than 220 thousand tons of grapes are harvested annually in Georgia. The vast majority of this harvest ends up in different wineries and gets pressed for wine. Interviews were conducted with the major wine producers to examine the potential amounts and conditions of potential waste from wineries.

There are two major types of wineries – 1. Those who rely mostly on own vineyards 2. Those who also purchase the considerable amount of grapes from farmers. The first category mostly uses the wine pressings as fertilizer in own vineyards the second category stores this excess biomass on the own territory.

In previous years some amount of the pressed grape residues (chacha) was sold back to farmers, however it is noteworthy that from 2014 the state has prohibited sales of pressed remains to third parties and therefore the wineries of second type are now facing a significant challenge of disposing of their waste pomace.

The site visit was conducted to the premises of Bagrationi 1882 in order to understand the typical situation with the winery waste in the wineries of second type. A huge amount of residual pomace was found on the territory of the winery. There is a large reservoir completely filled up with this biomass and the recent additions now form the small hills on the territory of wine factory (cf. picture below)

Picture 22. Accumulation of grape pomace in "Bagrationi 1882" winery.

There is a small business operating on the territory of Bagrationi 1882 who produces the grape seed oil and the pellets from remaining skins and pulp of grapes after its pressing. However the scale of their operations is incomparable to the amount of pomace annually accumulated

The mass of the grapepomace was examined by digging the pomace mass and found to be wet beneath the surface.

Picture 23 Pomace condition – wet

Telephone interviews were conducted with the management of some of the leading wineries and the results are summarized in the table below.

Table 1 : Results of telephone inquiry with the leading wine producers in Georgia.

All wineries of second type express their willingness to dispose of the accumulated pomace mass. It is

Name of winery	Total (own) Amount of grape processed tons	annual accumulation of pomace (tons)	Accumulated	Willingness to dispose
Bagrationi 1882	2000 (?)	600	Huge reservoir overfilled	Yes
Badagoni	1000 (500)	300	500	Yes
Telavi Wine Cellar	5000(3000)	1500	1000-1200	yes
Armunji (Kindzmarauli Corporation)	1000-1200 (?)	300	Fertilizer for own vineyards	No
Shukhmann wineries	700-1000	18%	Fertilizer for own vineyards	No

noteworthy that there is a strict control from the state on disposal of residues, to avoid their recycling for secondary wine making.

One can conclude that there is a huge amount of waste biomass available for utilization and use for energy purposes. However the usefulness of this type of biomass for production of advanced biofuels needs to be understood. Internet search has been conducted in order to examine the best world practice in recycling and utilizing the winery residues.

Availability of biomass recycling

Farmers in general think that they do not have financial resources to invest in waste recycling process and there are no alternate sources for funding (credit, grant, etc).

However there are different cases. For instance, pellet and briquette plant, in the village Manavi, Kakheti, was funded by a cheap credit within the state program “Produce in Georgia”. Program representative said that despite the production chain is not completed yet, two types of production were produces in previous year. Initial price for punning is 60 GEL, but after placing on the final market it is worth 120 GEL. 2.5 kg packages of briquettes were produced for the first season and the price for them is 6 GEL. In some cases, plants also produce vine punning packages for barbeque. The main customers for this product are big supermarket and individuals.

The cost of raw material of briquettes is approximately 0.41 GEL/kg. Due to the high cost of the technological process the price of briquette is about 0.8 GEL/kg. Taking into account that the price for natural gas is 0.75 GEL/m^3 and the population does not have additional costs (such as transportation cost etc.), briquette market is not very attractive at this moment.

Example of Shida Kartli intensive gardens appeared to be very interesting. The owners of these gardens said that they do not withdraw the waste of apple and other fruit. However, they cut the waste into pieces

with special equipment and leave it in the garden as mulch. Mulching of the soil improves its agro-physical qualities and protects it from erosion. The plants help to enrich the soil with organic mass. Mulching affects physical, biological and chemical processes in the soil. Mulch is more important for arid regions because it hinders erosion. It protects the soil aggregates from precipitation. It should be noted that straw and stubble are also very good raw material, but 60% of these wastes are used for animal feed, which is very unproductive without additional admixtures.

We asked farmers to indicate the waste markets. 80% of respondents said that they do not have any information about this kind of service.

Conclusions

To sum up, there is a significant amount of unutilized biomass residue available in Georgia which can be successfully used by businesses to produce pellets, briquettes or other types of modern biofuels. Georgian market is almost completely untapped in this regard.

5. From agriculture the following crops have high potential:
    - **Vineyard and orchard pruning residues** - The amount of vine cutting residues is higher than estimated in the desk study by some 10-20% and amounts to 3.2-3.5 tons per hectare. 90% is being burned soon after cutting in early springs.
    - **Winery residues –** several big wineries have annual accumulation of pressed pomace of several hundred tons and have difficulty of its disposal
    - **Bay fine branches** remaining from bay leaf harvesting with high concentration in Khobi municipality.
    - To a less extent **wheat** (mostly in Kakheti- Dedoplistskaro) and potentially the **sunflower.**
    - The residues of other crops have alternative uses and are less likely to be available for energy.

Most farmers are paying for removal of residues from their orchards and wineries and will be glad to have some sort of alternative resolution for waste disposal.

1. From Forestry operations:
    - High accumulation sawdust and potential annual addition has been observed in sawmills in several regions of Georgia. The amount of available sawdust varies between several hundred to several thousand cubic meters with variable quality and mostly high moisture content of about 40%. The detailed maps with indication of potential amounts and accessibility are available on website www.**biomass.ge**. The full GIS database is available on demand.
    - High amounts of remaining tree trunks, big branches and logs have been found in the areas of illegal cut that are left in place as physical evidence and are not allowed to be used by population. The estimated amount is about 4-5m^3/ha. Less amount is available from licensed territories.
    - Residues potentially available from bush removal. The field estimates indicate that bout 10 m^3/ha of biomass can be obtained by removing the Rhododendron bushes which may result in 50000m^3 of biomass available from 5000ha of territory 80% dominated by these bushes.

- There are estimated several thousands of cubic meters of tree trunks accumulated in Enguri HPP reservoir, that can be used as a fuel, however there is no permission to collect and use this biomass

6. Costs of waste removal
    - The typical cost of removal from the hectare of orchard or vineyard is about 40-50GEL.
    - The daily worker hiring costs 25 GEL in East Georgia regions
    - The cost of cleaning up the average vineyard of 10-15 ha is 400-600GEL while for orchards in Kartli 300-400GEL
    - One route to the forest with the big three driving axes Ural truck costs 300-400 GEL
7. The study has revealed several inefficiencies in biomass residue management causing problems to owners and resulting in environmental damage:
    - Lack of legal disposal sites for sawdust from sawmills and associated fines are causing the owners to store the sawdust in their territories, burn it illegally or cause significant damage by disposing in river gorges.
    - Common problem is burning of residual biomass from perennial and annual crops. This includes burning of the big amounts of orchard, vineyard cuttings and fine bay branches; field burning of remaining stems and roots of wheat and barley. In many cases this is illegal but also causes damage to the fields.
    - Residues of a number of big wineries are left in the open air and are accumulating causing logistics and disposal problems to the owners.
    - Burning causes GHG emissions without any accompanying energy benefit.

Developing of solid biofuel production could avoid these useless emissions and local environmental damage, and allow to produce the energy in a sustainable way.

Recommendations

- Legal treatment of illegal cuts in forests should be made more flexible to allow utilization of the residues
- The feasibility of chipping and removing the residues from forests needs to be studied for tending and trimming, bush removal and residues of tree harvesting
- The forestry agency should promote the early tending and trimming operations as well as bush removal and could combine this with production of biofuel production from residues thus combining the environmental and forestry benefits with energy production.
- Promotion of knowledge on modern biofuels and advanced burning equipment would be highly beneficial for population of the regions.

These problems can be successfully resolved with more informing, flexible legal measures allowing the population to make the use of available biomass, and/or with deployment of advanced solid biofuel production and utilization technologies.

Annex 1 – Questionnaire for Sawmill Survey

ზოგადი ინფორმაცია

ინტერვიუს თარიღი	2. ინტერვიუერის სახელი	3 ობიექტის ნომერი

4 ადგილმდებარეობა

რეგიონი	რაიონი	მისამართი	მფლობელი	GPS კოორდინატები

შენიშვნა

5 გამოკითხულის ვინაობა

სახელი და გვარი	თანამდებობა	მობილური ნომერი	ელ. ფოსტა

6	რომელი/რამდენი წლიდან/წელი მუშაობთ	თანამშრომლების რაოდენობა	მისასვლელი გზის მდგომარეობა (რა ტიპის მანქანის მისვლაა შესაძლებელი)
			1 2 3

7	ძირითადი მოწყობილობების ტიპები და მაქს. სიმძლავრე	8	გადაიღეთ სურათები (2-3) და მონიშნეთ ეს უჯრა

9 გადამუშავებული ხე-ტყის მასალის წლიური რაოდენობა

შენიშვნა

	2014	2013	2012
მთლიანი რაოდენობა			
რაოდენობა ხის სახეობების მიხედვით			
1ჩიჩეოვნები			
2			
3			
4			
5			

0 სამხერხაოს სამომავლო საქმიანობის გეგმები

არსებულ კონტრაქტების საფუძველზე	კერძო შეკვეთების საფუძველზე

11 ტექნოლოგიური გაუმჯობესების სავარაუდო გეგმები

ახალი დანადგარების შემენა	სარეაბილიტაციო სამუშაოები	სხვა (დააკონკრეტეთ)

დეტალური ინფორმაცია

2 ხე-ტყის წყარო

საკუთარი ტყე-კაფი

3 1 მ3 ნიწვოვანი სახეობების პირველადი გადამუშავების შედეგად მიღებული ნახერხის და სხვა ნარჩენის რაოდენობა (პროცენტებში)

მსხვილი ნარჩენები	ნახერხი და ბურბუშელა	ქერქი	სხვადასხვა დანაკარგე

4 1 მ3 ფართოფოთლოვანი სახეობების პირველადი გადამუშავების შედეგად მიღებული ნახერხის და სხვა ნარჩენის რაოდენობა (პროცენტებში)

მსხვილი ნარჩენები	ნახერხი და ბურბუშელა	ქერქი	სხვადასხვა დანაკარგე

5 1 მ3 მეორადი გადამუშავების შედეგად მიღებული ნახერხის და სხვა ნარჩენების რაოდენობა (პროცენტებში)

ნახერხი და ბურბუშელა	სხვადასხვა დანაკარგები
მეორადს არ აკეთებენ	

6

სამხერხაოს ნარჩენების წლიური რაოდენობა	სამხერხაოს ნარჩენების დაგროვილი რაოდენობა
105 მ3	53 მ3

ნახერხის და სხვა ნარჩენების შეფასება

17 ნარჩენების გატანა

სამხერხაოს ტერიტორიაზე, აღწერეთ გატანის ადგილი და ზომა	სამხერხაოს ტერიტორიის გარეთ, აღწერეთ გატანის ადგილი (რა მანძილზეა სამხერხაოსგან, რამდენად მისასვლელად ხელმისაწვდომია)

18 მესამე პირი თუ იღებს ნარჩენებს? ან არის თუ არა გაყიდვების გამოცდილება? დააკონკრეტეთ პირობები

დააკონკრეტეთ სახელი, შეთანხმება, ნაღებული რაოდენობა და სიხშირე	დააკონკრეტეთ მესამე პირი რისთვის იყენებს ნარჩენებს

19 რა სიხშირით ასუფთავებს სამხერხაო ტერიტორიას ნარჩენებისგან და რამდენია გატანილი ნარჩენების მოცულობა

ნარჩენების გატანის სავარაუდო ხარჯი

20

ნარჩენების მდგომარეობა	რაოდენობა	აღწერეთ მდგომარეობა/ტენიანობა	გატანის სირთულ (3 – ყველაზე რთულ
ახალი ჩაღები			1
მშრალი			2
დამპალი			3

22 ნარჩენების დღევანდელი გამოყენება

24 სამომავლო საქმიანობაში დაგეგმილი ნარჩენების გატანა

სჭირდება დახმარება	საკუთარი სახსრებით გატანა	საკუთარი მოხმარება ტექნოლოგიურ პროცესში	მესამე პირის მიერ წაღება (დააკონკრეტეთ)

ტყეში ნარჩენების კვადკოპტერით გადაღება

კომენტარი

Annex 2 – results of sawmill survey

N	საიმედოობა	ჯარიმა	ადგილზე ნარჩენების რაოდენობა	ნარჩენების წლიური რაოდენობა	ნარჩენების მდგომარეობა	გატანის სირთულე	მისამართი	საკო ინფ
454	საიმედო	2000	1	2	დამპალი	2	საჩხერის რაიონი სოფ.კორბოული	მაჭა ალე 593
520	საიმედო	YES	12	120	სველი	1	საჩხერე, ფეიქართა ქ. 10	ნოზა 595
428	საიმედო	No	2	3	მშრალი	2	ჭიათურის რაიონი სოფ ხრეითი	ხვე ნ 551
469	საიმედო	No	550	500	სველი	1	საჩხერის რ-ნი, სოფ. საირხე აღმაშენებლის 2	გაბა 595
510	საიმედო	No	0	0	სველი	1	ზესტაფონის რაიონი, დაბა შორაპანი	ძაბირ 557
464	საიმედო	YES	9		სველი	2	ჭიათურის რ-ნი, სოფ. ხრეითი	ცერც 595
128	საიმედო	10000	7500	15	სველი-დამპალი	2	ადიგენის რაიონი სოფ. ჩორჩანი	მაჭა რევაზ
110	საიმედო	YES	6	4	სველი	1	ახალციხის რ-ნი სოფელი ტყემლანა	კა ჯა 595
122	საიმედო	No	24	50	სველი	1	ქ. ახალციხე, ახალქალაქის გზატკეცილი	ტ კა 595
90	საიმედო	YES	0	NA	სველი	2	ასპინძის რაიონი სოფელი ივერია	ღორ ლაშა
125	არასაიმედო	10000	NA	30	სველი	2	ადიგენის რ-ნი, სოფ. შოლავერი	ტოფ 593
164	საიმედო	No	1	0	სველი	1	ქ. ახალციხე, ივანე ახალციხელის ქ. 61	ნათე 595
92	საიმედო	YES	0	16	სველი	1	ახალციხის რაიონი სოფელი კლდე	ბლუ რ 598
91	საიმედო	No	0	18	სველი	1	ახალციხის რაიონი სოფელი გიორგიწმინდა	კაველ 555

187	საიმედო	500	1	5	სველი-მშრალი	1	სენაკის რაიონი, სოფელი თეკლათი	გვარა 597
193	საიმედო	5000	5	20	სველი-მშრალი	1	მარტვილის რაიონი, სოფელი გაჭედილი	ბაღ თ 593
256	საიმედო	800	3	40	სველი-მშრალი	1	სენაკის რ-ნი, სოფ. თეკლათი	გრ მ 597
255	საიმედო	2000	5	60	სველი-მშრალი	1	მარტვილის რ-ნი, სოფ. თამაკონი	ჯ თ 555
198	საიმედო	2500	3	25	სველი-მშრალი	1	ქ.სენაკი ჯიხას ქ#21	სიგუ
213	საიმედო	2000	2	40	სველი-მშრალი	1	სენაკის რაიონი, სოფ. თეკლათი, კეცხოველის ქ.#8	წუ ე 597
276	საიმედო	20000	2	150	სველი-მშრალი	1	სენაკის რ-ნი, სტალინის მე-2 ჩიხი	ცხ ამ 599
181	საიმედო	10000	30	500	სველი-მშრალი	1	მარტვილის რ-ნი სოფ.ტალერი	დოს 568
186	საიმედო	16000	7	60	სველი-მშრალი	1	ჩხოროწყუს რაიონი სოფელი თაია	გაბედ 577
522	არასაიმედო	No	0	0	0	1	ბაღდათის რ-ნი, სოფ. დიმი	გეგე 599
418	საიმედო	No	3	28	სველი	1	ვანის რაიონი,სოფელი ციხესულორი	ფუ შოთა
414	საიმედო	440	3	45	სველი	1	ქალაქი თერჯოლა,რუსტაველის ქუჩა #2	ლუტ 598
521	საიმედო	2000	6	40	მშრალი	1	ქ. ქუთაისი, ლომოურის ქ.17	უგ იზ 599
460	საიმედო	No	2	17	სველი	1	წყალტუბო სოფ.ყუმისთავი	მაღ ავთ 598
518	საიმედო	No	15	660	სველი	1	თერჯოლის რაიონი, სოფ. ეწერი	ჩიკაშ 599
508	საიმედო	70000	30	400	სველი	1	ქ. ქუთაისი, ავტომშენებლის ქ. 88	ვანგ 599 ვესაუ ვარ
517	საიმედო	100000	20	500	დამპალი	1	ქ.ვანი ტაბიძის ქ. 7	მორ ვა 599

485	საიმედო	20000	2	320	სველი	1	ბაღდათის რ-ნი, სოფ. ვარციხე	ტაბეშ 551
265	საიმედო	No	5	350	სველი-მშრალი	1	ქ. ზუგდიდი, ჯანაშიას ქ. 1	თოდ 593
269	საიმედო	2000	5	200	სველი-მშრალი	1	წალენჯიხის რ-ნი, დაბა ჯვარი, ყაზბეგის ქ. #5	ჭან კახაბ 579
237	საიმედო	No	2	50	სველი-მშრალი	1	წალენჯიხის რ-ნი, სოფ. ნაკიფუ	აბულ 591
230	საიმედო	No	6	45	სველი-მშრალი	1	წალენჯიხის რ-ნი, სოფ. ნაკიფუ	ზარქ 593
271	საიმედო	No	5	130	სველი-მშრალი	1	წალენჯიხის რ-ნი, დაბა ჯვარი, გაფრინდაშვილის ქ.	ჭანტ 568
272	საიმედო	No	3	100	სველი-მშრალი	1	წალენჯიხის რ-ნი, დაბა ჯვარი, გაფრინდაშვილის ქ. 2	კვარ აბ 577
204	საიმედო	2500	3	10	სველი-მშრალი	1	ჩხოროწყუ, სოფ. ხაბუმე	ახ ნიკ 599
275	საიმედო	no	100	1200	სველი-მშრალი	1	წალენჯიხის რ-ნი, სოფ. ლია	ვანგ გ 591
369	საიმედო	500	2	0	მშრალი	1	თელავი სოფ. ნაფარეული	გომ ზაზა 571058 ჭერ მე
380	საიმედო	No	20	936	მშრალი	1	თელავის რ-ნი, სოფ. კონდოლი	სუხი თ 595
379	არასაიმედო	150	30	150	სველი	1	ყვარელი თაყაიშვილის 44	რუს ო 595
387	საიმედო	1000200	3	70	მშრალი	1	ყვარლის რ.ნ. სოფ. შილდა	უთუ იოსებ
406	საიმედო	346000	12	200	სველი	1	ყვარლის რ-ნი, სოფ. ახალსოფელი	არჩ გ 595
409	საიმედო	YES	132	15	სველი-მშრალი	1	ყვარლის რაიონი, სოფ. ახალსოფელი	მაზა რ 599
3	საიმედო	YES	350	NA	სველი	3	ქარელის რ-ნი გვერძიწეთი	მაი მ 551

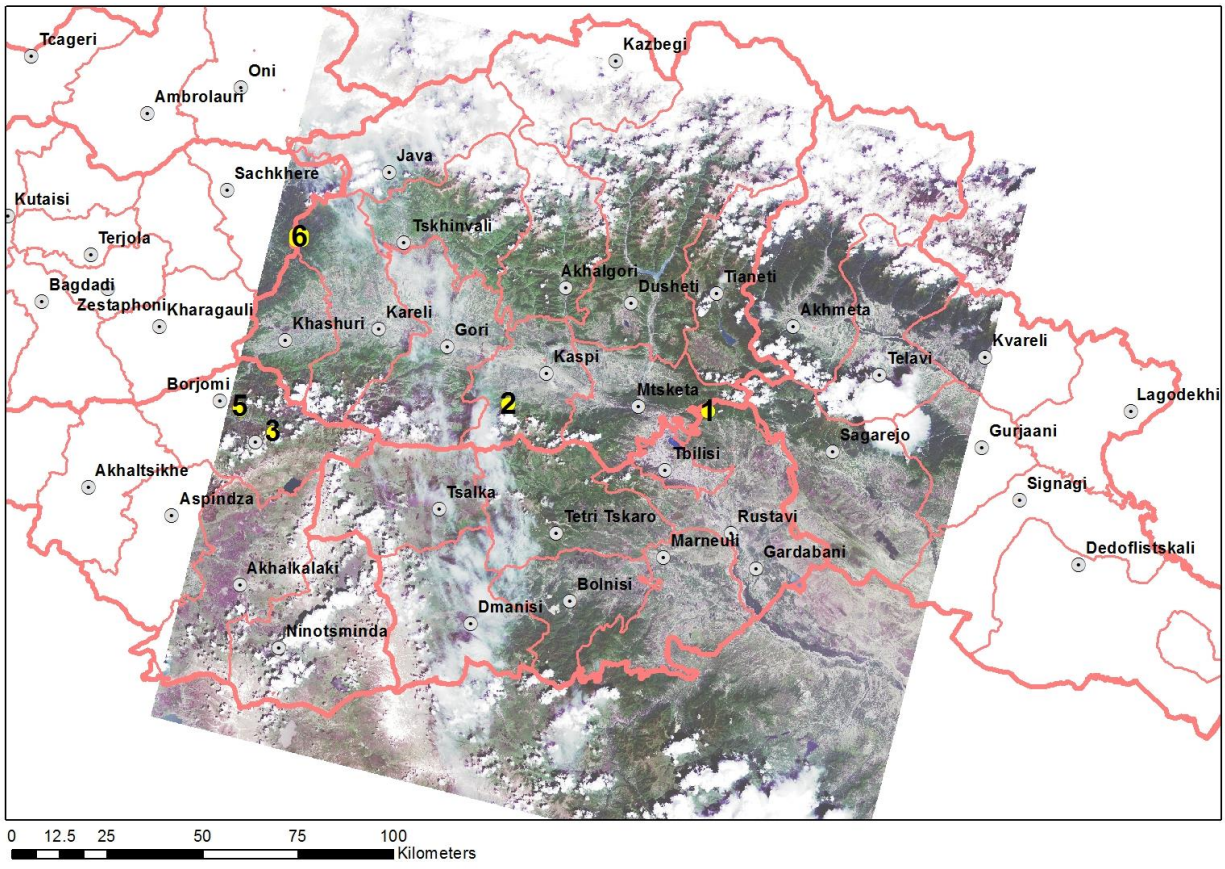
49	საიმედო	8000	5	NA	მშრალი	1	ხაშურის რ-ნი, სოფ. ცხრამუხა	ხაჩი ვლა 595
54	საიმედო	NA	300	100-150	სველი-მშრალი	1	ხაშურის რაიონი, სოფ. ხცისი	ბერი 595
44	საიმედო	No	53	105	სველი-მშრალი	1	ბორჯომის ქ. #4	ტა რაგუ 59964 595
1002	საიმედო	No	24	NA			ონის რაიონი, სოფელი ჯინჭვისი	მეტ ამ 551
1003	საიმედო	200	254	NA	სველი-მშრალი-დამპალი	1	ამბროლაურის რაიონი, სოფელი სადმელი	სიხა კობა 5
349	საიმედო	2000	700	60	სველი-მშრალი	1	ქ. ონი, ვახტანგ VI-ის ქ. #58	გავაშე ალე 598
343	საიმედო	2000	265	60	სველი-მშრალი	1	ონის რ-ნი, სოფ. ჯინჭვისი	მეტ ნ 551
350	საიმედო	4000	350	350	სველი-მშრალი	1	ქ. ონი, ვახტანგ VI-ის ქ. 156	გა მ 595
348	საიმედო	2000	600	NA	სველი-მშრალი	1	ონის რ-ნი, სოფ ღარი	მაღ დ 595
322	საიმედო	NA	600	NA	სველი-მშრალი	1	ამბროლაურის რ-ნი, სოფ.თლუღი	ტყეშე დ 551
320	საიმედო	NA	390	600	სველი-მშრალი	1	ამბროლაურის რ-ნი, სოფ. კვაცხუთი	ჯა დავი 577
345	საიმედო	NA	0	0	სველი-მშრალი	1	ონის რ-ნი, სოფ. ღარი	ჯა გრ 595
308	საიმედო	4000	35	NA	სველი-მშრალი	1	ქ. ამბროლაური, ვაჟა ფშაველას ქ.	დონა 595
342	საიმედო	NA	254	NA	მშრალი	1	ონის რ-ნი, სოფ. წმენდაური	რაზმ 595
284	საიმედო	NA	600	1600	სველი-მშრალი	1	მესტიის რ-ნი, სოფ. ხაიში	გვ ლა 595
285	საიმედო	YES	10	30	სველი		მესტიის რ-ნი, სოფ. ხაიში	ჭკადუ გრ 595

242	საიმედო	NA	5	90	სველი-მშრალი	2	მესტიის რ-ნი, სოფ. ჭუბერი (ლარილარი)	გურჩ 595
279	საიმედო	YES	15	400	სველი-მშრალი	3	მესტიის რ-ნი, სოფ. ხაიში	ჭკადუ ზოსმე
281	არასაიმედო	YES	5	300	სველი-მშრალი	2	მესტიის რ-ნი, სოფ. ჭუბერი	ცინც ჯ 551
1004	საიმედო	No	20	10	სველი-მშრალი	2	მესტიის რაიონი, სოფელი ჭუბერი	ჯაჭ ზ 599
654	საიმედო	YES	0	29	სველი-მშრალი	2	ქ. ქობულეთი, მესხიძის ქ. 13a	ცეცხლ 568
645	საიმედო	No	10	125	სველი-მშრალი	2	ხელვაჩაურის დასახლება სამრეწველო ზონა	აბულ 555
627	არასაიმედო	4000	90	24	სველი	2	ხულოს რ-ნი, სოფ. სკვანა	გია ც 577
571	საიმედო	No	300	840	სველი	1	ხელვაჩაური, სოფ.მეჯინისწყალი	არა მე 599
642	საიმედო	No	2	0	სველი		შუახევის რ-ნი, სოფ. ვანი	ცენ თემ 577
644	არასაიმედო	No	6000	100	სველი-მშრალი	2	ქ. ქობულეთი, თავისუფლების შესახვ. 28	გიგლ 593
596	საიმედო	No	50	84	სველი	2	ქ.ქობულეთი, თავისუფლების ქ.#77	ქათა ხემზე
1005	საიმედო	No	0	0	სველი	1	ქ. ჩოხატაური, კოსტავას 3.	ჯიბ გრ 599
551	საიმედო	No	20	450	მშრალი	2	ჩოხატაური, კოსტავას ქ. #3	ჯიბ მ 551

Remote Sensing as a tool for the residual biomass assessment in Georgian Forests - First approach study

Introduction and Scope

Landsat Thematic Mapper (TM) data with suitable spectral and spatial resolution and relatively long time series of data availability have made it a primary data source for biomass estimation. However, it does have a critical limitation in terms of pixel resolution and dependence on meteorological conditions. The remote sensing-based biomass estimation methods assume that forest stand information captured by sensors is highly correlated with aboveground biomass. According to this assumption, the keys for biomass estimation are to use appropriate variables and to develop suitable estimation models if sufficient sample plots are available. Many new variables such as vegetation indices and textures can be calculated from the multispectral bands. Aboveground forest biomass estimation with Landsat TM spectral signatures and vegetation indices can be improved and calibrated by sub-pixel textural images, i. e. combination of spectral response and textural images can effectively improve biomass estimation performance, especially in the areas with complex forest stand structures.



Pic 26 *Landsat 8 satellite image, selected for present study 18 May, 2015. With yellow spots and numbers are shown local forestry sites, studied in high resolution by means of*

Aerophotogrammetry from quadcopter. #1 Martkofi, #2 Ertatsminda, #3 Mitarbi, #5 (and #4) Borjomi 1 and 2. #6 represents well preserved forest site, used for comparison of spectral signatures[12].

In our case high resolution aerophotogrammetric shooting of selected Forest sites was used as a ground truth for general resolution products derived from Landsat Multispectral image. Field Aerial photo shooting was conducted at specified sites (see Fig. 1) during the months of May and June of present year (2015). Derived high resolution orthophotos were used to assess the forest condition and amount of available residual biomass per area. For more details please see corresponding report. Following values were derived (see Table 3) :

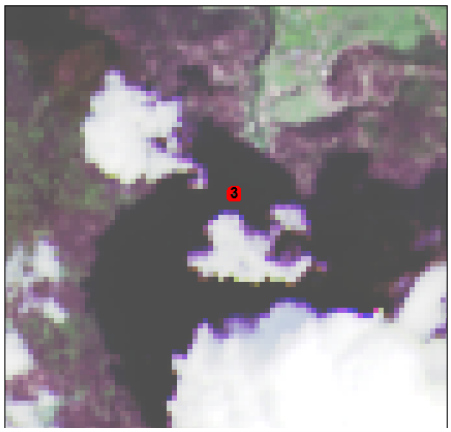
Table 3 *Estimated residual biomass at selected Forest site*

#	Name of site	Area (Ha)	Estimated Residual biomass (m3)	Res. Biomass per Ha (m3)	Comment
1	Martkofi	0.48	1.85	3.85	Site of forest cut
2	Ertatsminda	0.46	1.03	2.24	Site of forest cut
3	Mitarbi	0.14	8.30	59.29	Fallen trees
4	Borjomi 1	0.27	6.70	24.81	Burned forest During 2008 August war
5	Borjomi 2	1.10	67.08	60.98	Burned forest During 2008 August war

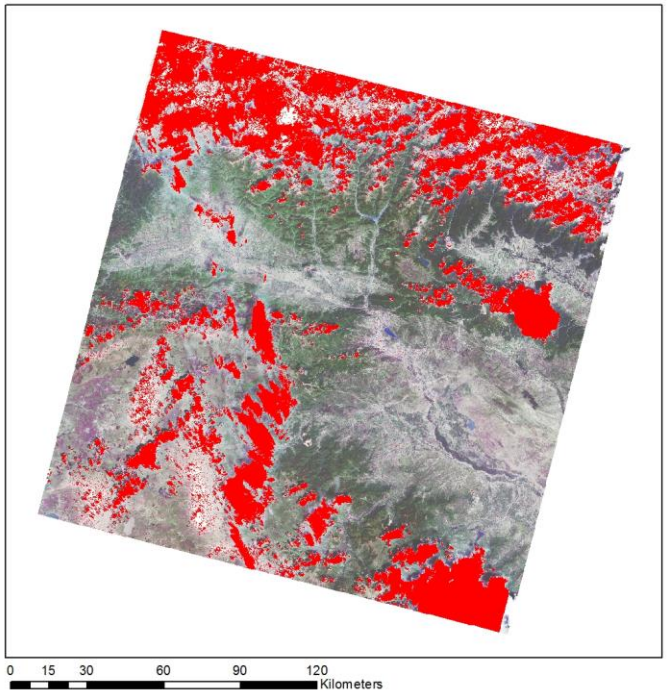
Landsat 8 Multispectral satellite image was selected for current study, we tried to search and download image shoot from satellite in the same time range in which aerophotogrammetric studies were conducted. As a best choice Image dated May 18, 2015 was selected (see Fig. 1). As one should know cloud cover always represent one of the main problems with satellite data quality. This problem becomes even more acute, than limited in choice of images due to short time window. In our case, still we got 30% of image covered by clouds (*29.8 % of total area 8400 sq.km of total 36 600*), though most of the field sites appeared to be located under clean sky. To avoid any misinterpretation and false values during the study, special cloud mask was constructed and applied during the analysis (See Fig. 2).

Unfortunately due to cloud cover we were forced to exclude selected forest site #3 in Mitarbi from our analysis, See image bellow:

[12] Video - https://www.youtube.com/watch?v=sqNQQz_RYA4



Selected forest site near MItarbi Excluded from analysis due to cloud cover



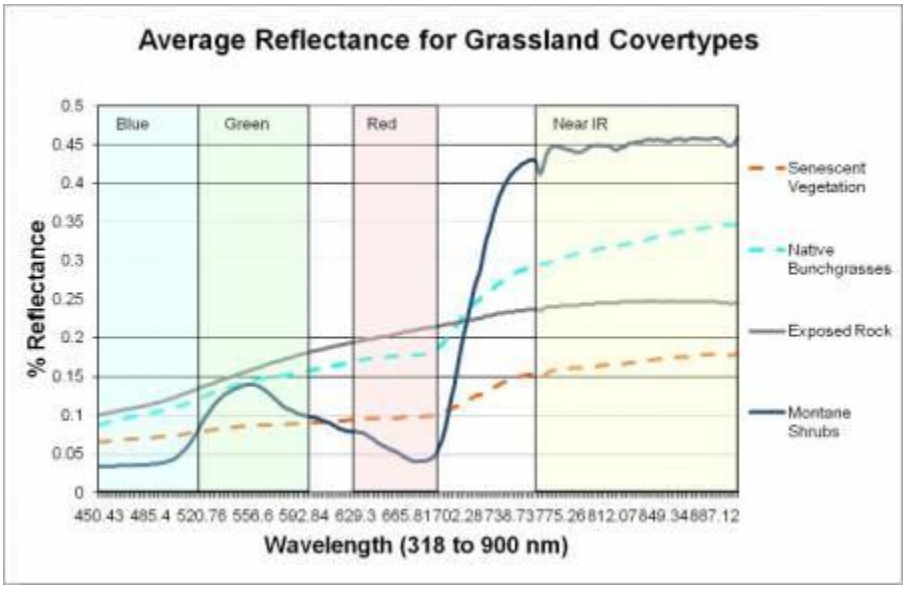
Pic. . *27, 28* *Cloud cover mask of study image. 29.8 % of total area (8400 sq.km of total 36 600)*

Methodology description

In order to derive thematic data for Landsat Image to indices, directly related with biomass and vegetation were used - Normalized Difference Vegetation Index (NDVI) and Normalized Difference Water Index (NDWI). Below is given a brief description of both, calculation methodology and scientific background. Derived NDVI and NDWI indices maps you can see in Figures 3 and 4.

NDVI

The Normalized Difference Vegetation Index (NDVI) is an index of plant "greenness" or photosynthetic activity, and is one of the most commonly used vegetation indices. Vegetation indices are based on the observation that different surfaces reflect different types of light differently. Photosynthetically active vegetation, in particular, absorbs most of the red light that hits it while reflecting much of the near infrared light. Vegetation that is dead or stressed reflects more red light and less near infrared light. Likewise, non-vegetated surfaces have a much more even reflectance across the light spectrum.



Pic. 29 Average Reflectance for Grassland Cover types

By taking the ratio of red and near infrared bands from a remotely-sensed image, an index of vegetation "greenness" can be defined. The *Normalized Difference Vegetation Index (NDVI)* is probably the most common of these ratio indices for vegetation. NDVI is calculated on a per-pixel basis as the normalized difference between the red and near infrared bands from an image:

$$NDVI = \frac{(NIR - RED)}{(NIR + RED)}$$

Where NIR is the near infrared band value for a cell and RED is the red band value for the cell. NDVI can be calculated for any image that has a red and a near infrared band. The biophysical interpretation of NDVI is the fraction of absorbed photosynthetically active radiation.
Many factors affect NDVI values like plant photosynthetic activity, total plant cover, biomass, plant and soil moisture, and plant stress. Because of this, NDVI is correlated with many ecosystem attributes that are of interest to researchers and managers (e.g., net primary productivity, canopy Fuller, D.O. 1998. Trends in NDVI time series and their relation to rangeland and crop production in Senegal, 1987-1993. International Journal of Remote Sensing 19(10):2013-2018.
cover, bare ground cover). Also, because it is a ratio of two bands, NDVI helps compensate for differences both in illumination within an image due to slope and aspect, and differences between images due things like time of day or season when the images were acquired. Thus,

vegetation indices like NDVI make it possible to compare images over time to look for ecologically significant changes. Vegetation indices like NDVI, however, are not a panacea for rangeland assessment and monitoring. The limitations of NDVI are discussed below.

The output of NDVI is a new image file/layer. Values of NDVI *can* range from -1.0 to +1.0, but values less than zero typically do not have any ecological meaning, so the range of the index is truncated to 0.0 to +1.0. Higher values signify a larger difference between the red and near infrared radiation recorded by the sensor - a condition associated with highly photosynthetically-active vegetation. Low NDVI values mean there is little difference between the red and NIR signals. This happens when there is little photosynthetic activity, or when there is just very little NIR light reflectance (i.e., water reflects very little NIR light).

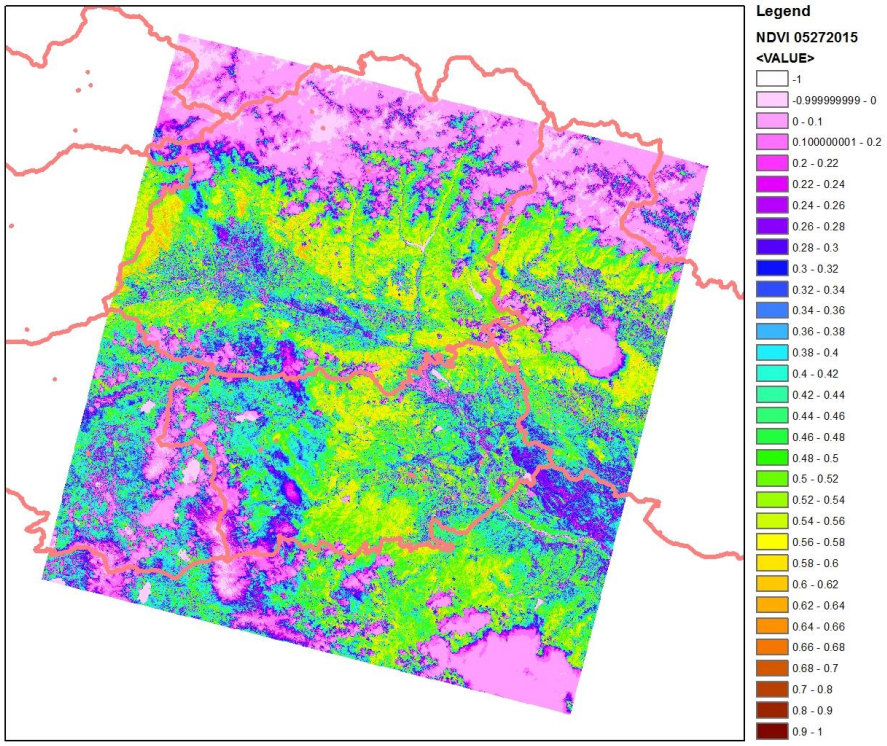
NDWI

During drought event, vegetation canopy can be affected by water stress. This can have major impact on the plant development in general and can cause crop failure or lower crop production in agricultural areas. Early recognition of plant water stress can be critical to prevent such consequences. By providing near-real time information on the plant water stress to the stakeholders, water and agricultural management can be much improved, notably by irrigating specifically areas where plant water needs are not fulfilled anymore. The Normalized Difference Water Index (NDWI) is known to be strongly related to the plant water content. It is therefore a very good proxy for plant water stress.

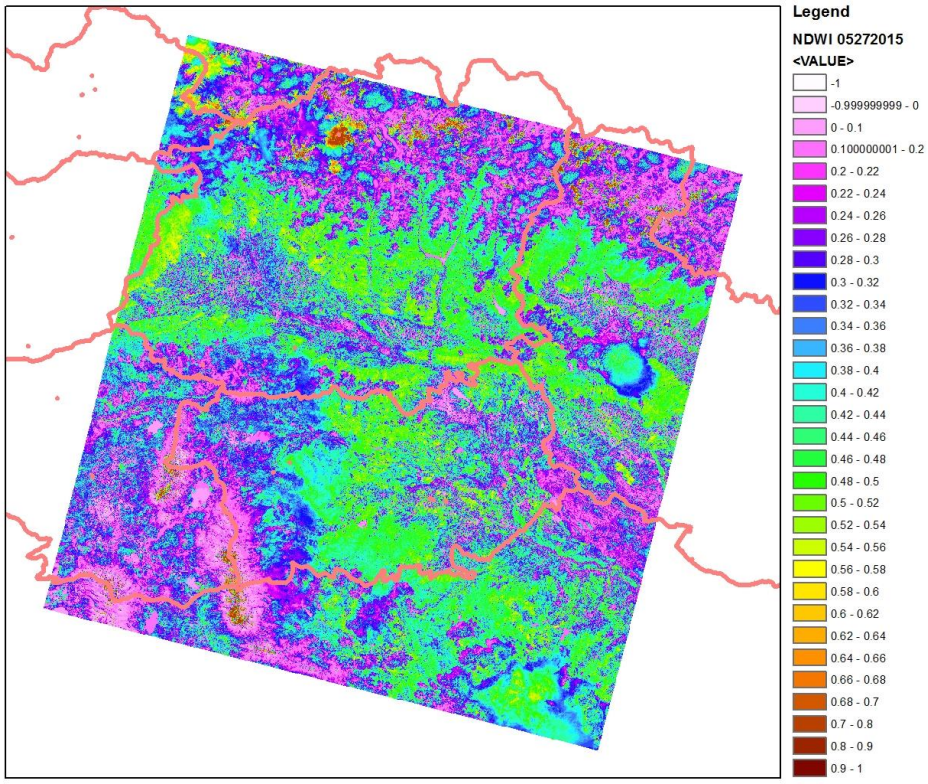
The Normalized Difference Water Index (NDWI) (Gao, 1996) is a satellite-derived index from the Near-Infrared (NIR) and Short Wave Infrared (SWIR) channels. The SWIR reflectance reflects changes in both the vegetation water content and the spongy mesophyll structure in vegetation canopies, while the NIR reflectance is affected by leaf internal structure and leaf dry matter content but not by water content. The combination of the NIR with the SWIR removes variations induced by leaf internal structure and leaf dry matter content, improving the accuracy in retrieving the vegetation water content (Ceccato et al. 2001). The amount of water available in the internal leaf structure largely controls the spectral reflectance in the SWIR interval of the electromagnetic spectrum. SWIR reflectance is therefore negatively related to leaf water content (Tucker 1980). The NDWI is a remote sensing based indicator sensitive to the change in the water content of leaves (Gao, 1996). NDWI is computed using the near infrared (NIR – MODIS band 2) and the short wave infrared (SWIR – MODIS band 6) reflectance's.

$$NDWI = \frac{(NIR - SWIR)}{(NIR + SWIR)}$$

Both NDVI and NDWI were calculated from Landsat 8 satellite image, fully convening necessary procedures and taking into account atmospheric corrections. Later on while analyzing spatial distribution of these indices, cloud mas was also applied to avoid mistreatment of data and false conclusions (Fir. 3 and Fig. 4).



Pic. 30 *Map of NDVI index from Landsat 8 satellite image of 18 May, 2015. Classified in details in a range of 0.2-0.7 values, typical for forest cover.*



Pic. 31 *Map of NDWI index from Landsat 8 satellite image of 18 May, 2015. Classified in details in a range of 0.2-0.7 values, typical for forest cover.*

Obtained results and conclusions

NDVI index is quite efficiently used to derive ground cover. In particular forest cover derived from new Satellite images could be a good source of data, helpful for estimation available forest resources and corresponding average residual biomass. But, in present study we tried to analyze NDVI and NDWI indices as possible spectral signature for forest condition and possible link with residue biomass volume. For this reason statistical distribution of NDVI and NDWI values were studied within the areas also studied with high resolution photogrammetric method. In addition "etalon" site of Well-preserved forest was also included as a benchmark for comparison. ArcMap GIS software package was used for complex analysis. Zonal Histogram tool was applied to construct normalized histograms for the indices variations within the selected forest sites (see Fig.5) and statics of the same parameters given in Table 2 bellow.

Table 4. *Statistics of NDWI and NDVI indices distribution withint the selected forest sites*

#	SITE	NDWI				NDVI			
		MEAN	MIN	MAX	STD	MEAN	MIN	MAX	STD
1	Martkofi	***0.48***	0.41	0.53	0.02	***0.54***	0.48	0.60	0.02
2	Ertatsminda	***0.52***	0.48	0.55	0.02	***0.58***	0.53	0.62	0.02
4	Borjomi 2	***0.37***	0.30	0.43	0.03	***0.50***	0.47	0.55	0.03
5	Borjomi 1	***0.44***	0.35	0.50	0.04	***0.53***	0.44	0.60	0.04
6	G Forest	***0.51***	0.40	0.57	0.03	***0.58***	0.43	0.65	0.04

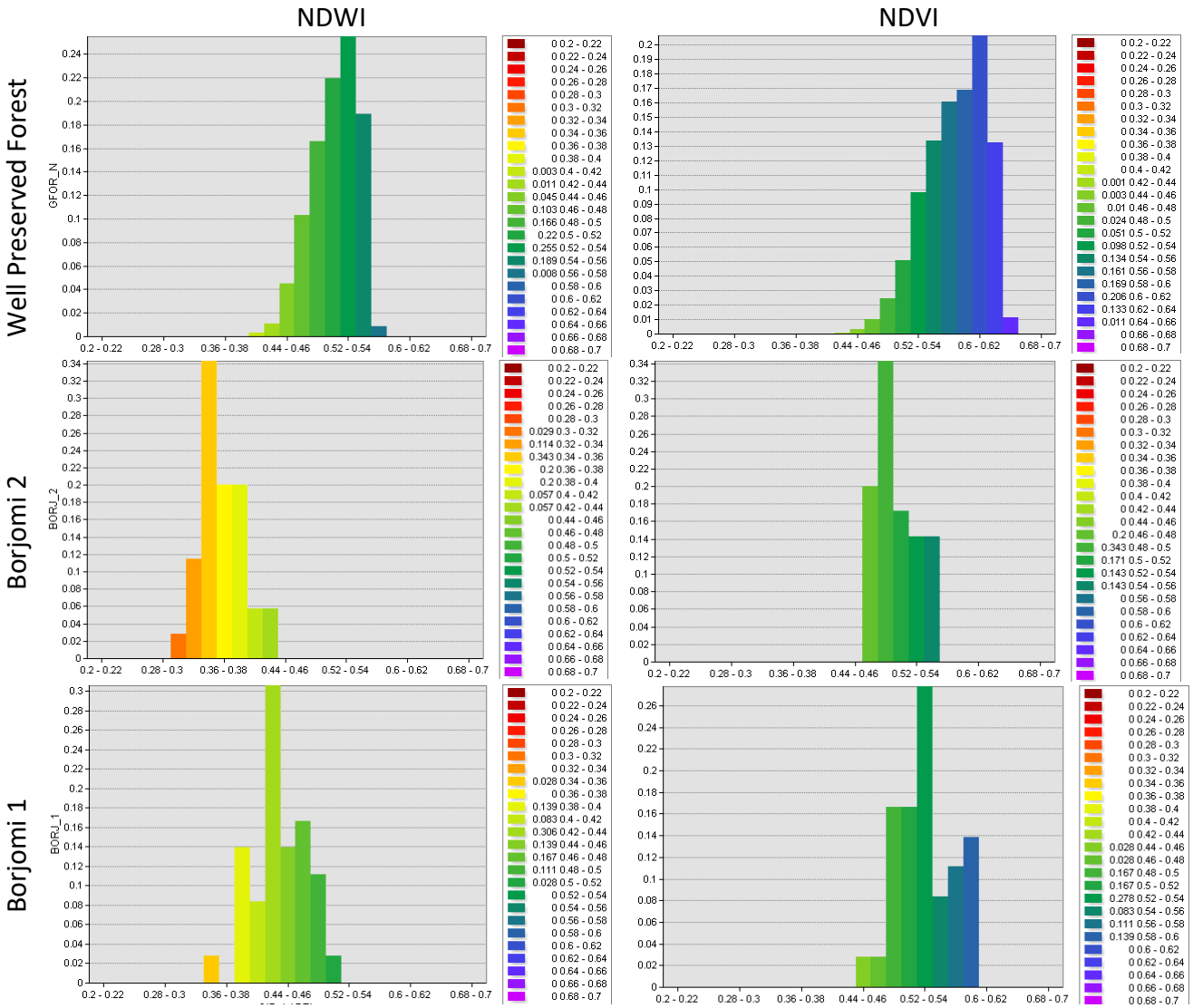
It should be mentioned that all the derived parameters, show quite small standard deviation values, thus being quite homogenous in their distribution. The same picture is observed in constructed histograms. As it was expected well preserved forest site selected as an "etalon" for comparison has shown the highest values for both Vegetative and Water indices (NDVI and NDWI) in average 0.58 and 0.51 respectively.

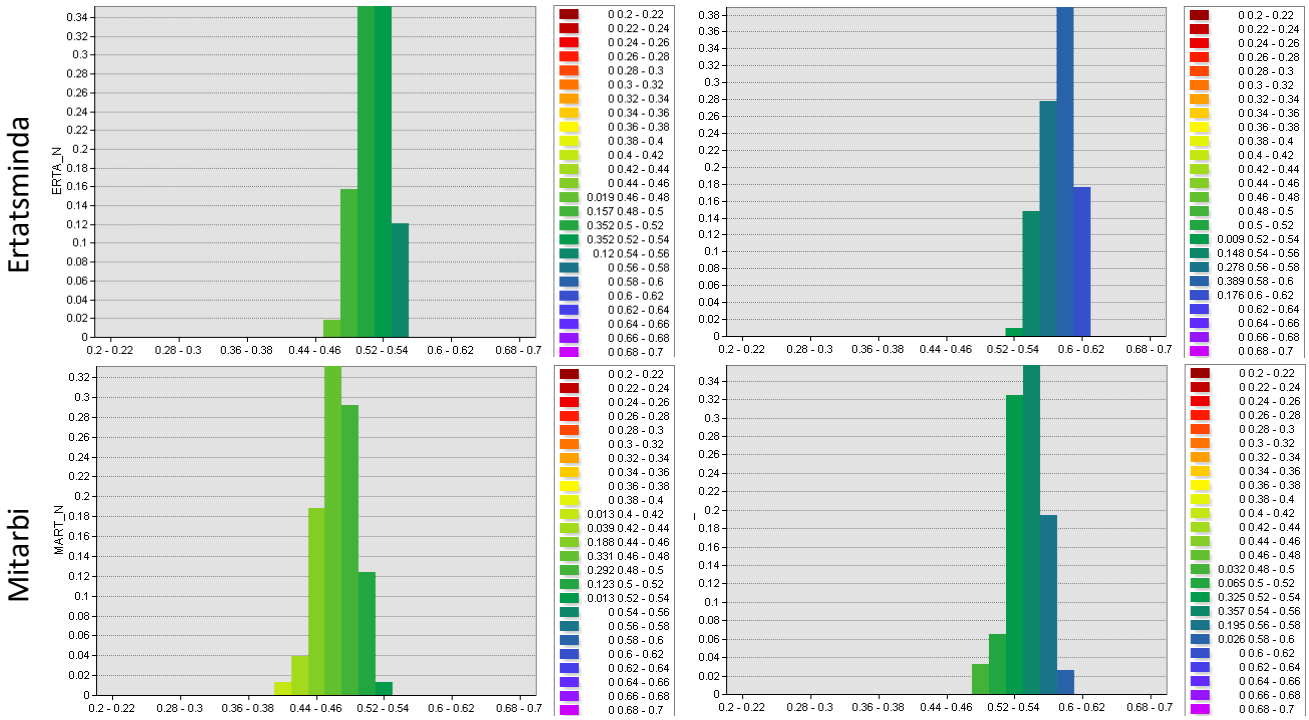
Borjomi 1&2 sites differ significantly from "etalon" showing the similar parameter behavior: NDVI – vegetative index rather low 0.50-0.53, but significantly different Water index NDWI values 0.33 - 0.44. These differences are even clearer looking at histogram graphs. As it was described above, both of these locations show Forest parcels heavily affected by fire, but still containing large volume of residue biomass in a form of fallen trees (appr. 60 m3 per Ha).

Results from #1-Martkofi and #2-Ertatsminda forest sites quite differ. #1 site at Martkofi represents forest parcels under cut, with significant amount of residue biomass in a form of left, unusable forest mass and branches (appr. 4 m3 per Ha). In this case we got different behavior of Vegetative and Water indices, both equally less than etalon values. NDVI value 0.54 and NDWI

value 0.48. While in Ertatsminda We got values equal to well preserved forest NDVI 0.52 and NDWI 0.58, where we have also significantly less residue amount (appr. 2 m3 per Ha), possibly comparable to natural value of fallen trees in forest.

In General we can conclude that General scale satellite images can be applied for overall assessment of forest conditions and respectively to residue biomass. Spectral signatures can be derived in a form of set of vegetative and water indices (NDVI and NDWI), though these might not be sufficient to achieve good resolution and other natural indexes should be investigated and incorporated in future studies.





Pic. 32 *Histograms for NDWI and NDVI values distribution within the selected forest sites*

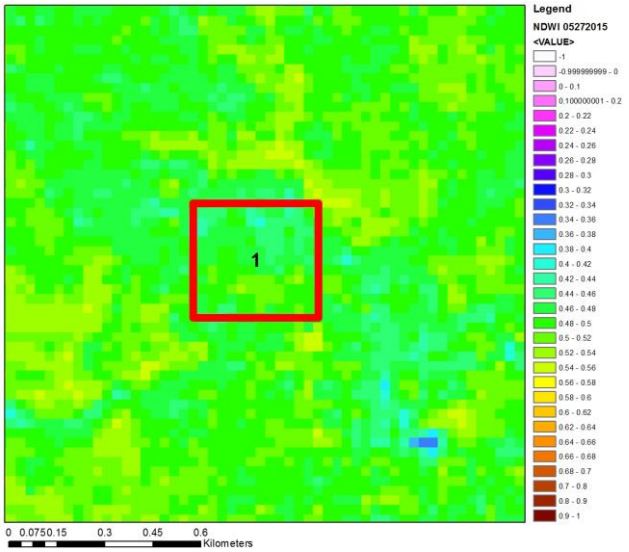
References:

1. Fuller, D.O. 1998. Trends in NDVI time series and their relation to rangeland and crop production in Senegal, 1987-1993. International Journal of Remote Sensing 19(10):2013-2018.
2. Wellens, J. 1997. Rangeland vegetation dynamics and moisture availability in Tunisia: an investigation using satellite and meteorological data. Journal of Biogeography 24:845-855.
3. Anderson, G.L., Hanson, J.D., and R.H. Haas. 1993. Evaluating landsat thematic mapper derived vegetation indices for estimating above-ground biomass on semiarid rangelands. Remote Sensing of the Environment 45(2):165-175.
4. Gao, B.-C. 1996. NDWI - A normalized difference water index for remote sensing of vegetation liquid water from space. Remote Sensing of Environment 58: 257-266.
5. Gu, Y., Brown, J.F., Verdin, J.P., and Wardlow, B. 2007. A five-year analysis of MODIS NDVI and NDWI for grassland drought assessment over the central Great Plains of the United States. Geophysical Research Letters 34.
6. Gu, Y., Hunt, E., Wardlow, B., Basara, J.B., Brown, J.F., Verdin, J.P. 2008. Evaluation of MODIS NDVI and NDWI for vegetation drought monitoring using Oklahoma Mesonet soil moisture data. Geophysical Research Letters 35.

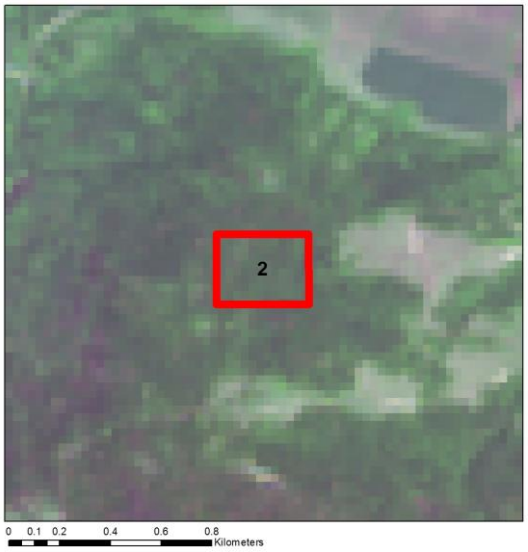
ANNEX 3 – RGB Image, NDWI and NDVI indices maps for selected forest sites

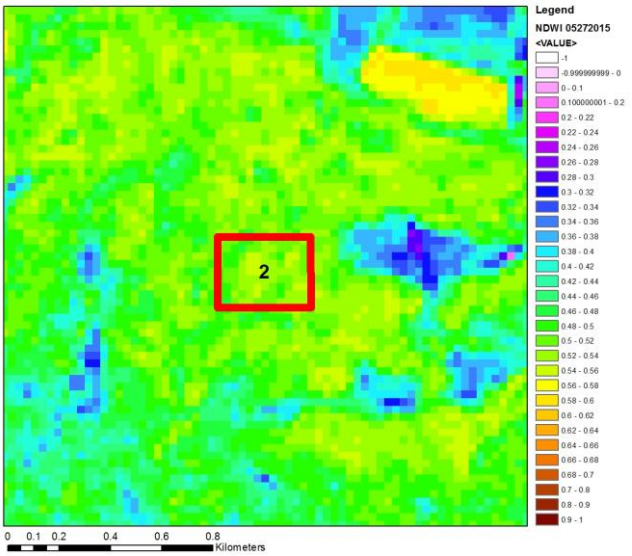
RGB image **NDWI**

#1 - Martkofi

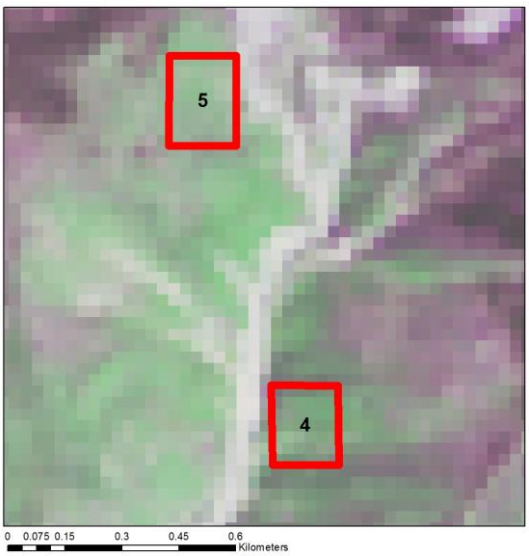


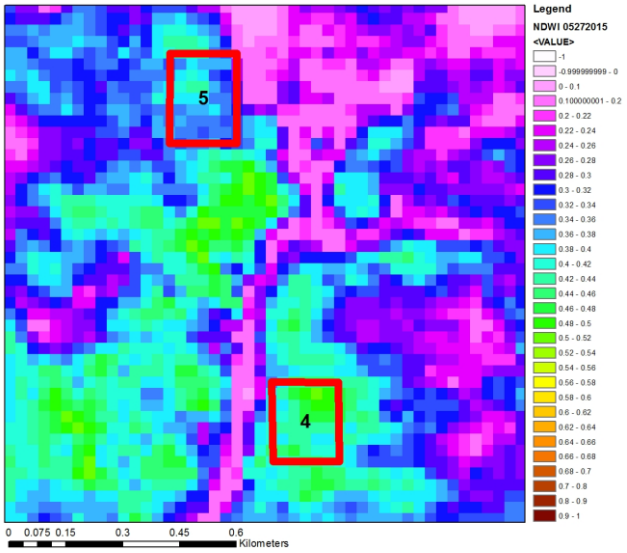
#2 - Ertatsminda

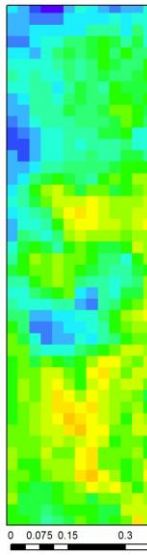




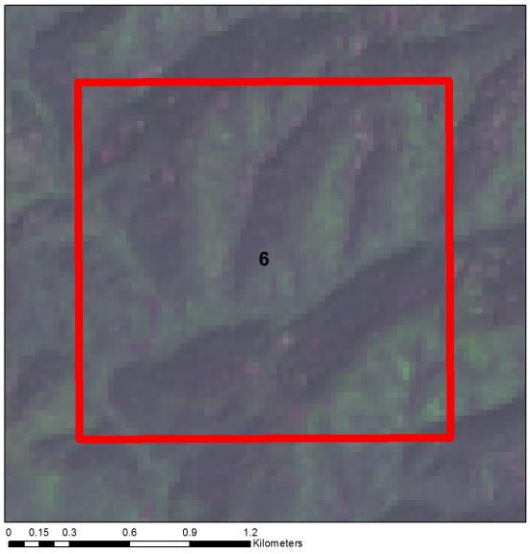
#4-5 Borjomi 1&2

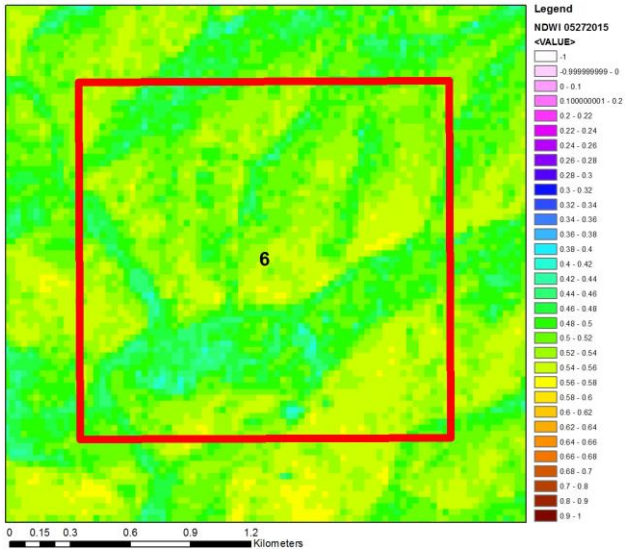


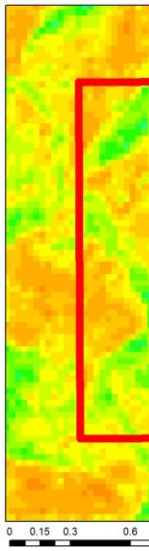




#6 Well Preserved Forest Sample







ANNEX 4 Survey results of Agricultural Biomass Residue from Annual and Perennial Crops in Georgia

#	რესპოდენტი	მუნიციპალიტეტი	ნაკვეთის ფართობ	კულტურა	ნარჩენის სახეობა	ნარჩენები (ტონა)	ნარჩენი (ტონა) ექსპერტული	ნარჩენის გატანის ღირებულება (ლარი)	ნარჩენების გამოყენება	თანხმობა ნარჩენების გაცემაზე

			ი (ჰა)				შეფასება			
კახეთი										
1	გიორგი ბეიბღია შვილი	ახმეტა	1	ვენახი	წალამი	0.1	0.1	20	პირადად მოიხმარენ	კი
2	იოსებ ჯავახიშვილი	ახმეტა	1	ვენახი	წალამი	0.8	0.8	50	პირადად მოიხმარენ	კი
			5	სიმინდი	ჩალა	4	4	50	პირადად მოიხმარენ	
3	გელა შათირიშვილი	ახმეტა	1	ვენახი	წალამი	0.7	0.7	თვითონ გამოაქვს	პირადად მოიხმარს	კი
4	ლევან შათირიშვილი	ახმეტა	1	ვენახი	წალამი	1	1	30	პირადად მოიხმარს	კი
5	ზაზა ფიროსმანაშვილი	დედოფლისწყარო	4.5	ხორბალი	ნამჯა	არა	არა		შიგვე აბრუნებს, ნამჯას საქონლის საკვებად იყენებს	არ აქვს ნარჩენი
6	ზაქრო გოგილაშვილი	დედოფლისწყარო	1500	სიმინდი, შვრია, ქერი, ხორბალი, მზესუმზირა	ჩალა, ნამჯა	არა	არა	92 ლარი უჯდება 1 ჰექტარი(მექანიზატორის ქირა)	სასუქად იყენებს	არ აქვს ნარჩენი
7	კობა ჭინჭარაული	დედოფლისწყარო	37	ხორბალი	ნამჯა	არა	არა		საქონლის საკვებად იყენებს	არ აქვს ნარჩენი
			70	ქერი	ნამჯა					
8	მერაბი მაძღარაშვილი	დედოფლისწყარო	4	ხორბალი, ქერი, სიმინდი	ჩალა, ნამჯა	არა	არა		საქონლის საკვებად იყენებს	არ აქვს ნარჩენი

9	ვანო გიგიტელაშვილი,	თელავი	5	ვენახი	წალამი	4	4	1000	იყენებს დროებით ღობედ, ხან წვავს ან პირადი მოხმარების თვის იყენებს	კი
10	ნიკოლოზ კირვალიძე	თელავი	0.25	ვენახი	წალამი	0.25	0.25	თვითონ ამუშავებს	პირადი გამოყენებისთვის ან წვავს თუ ბევრია	კი
			0.35	ატამი	ანასხლავი	0.25	0.25	თვითონ ამუშავებს		
11	ბონდო მიქაძე	თელავი	3	ვენახი	წალამი		0		პირადი გამოყენებისთვის ან წვავს თუ ბევრია	კი
12	ზურაბ წიგნაძე	თელავი	0.5	ვენახი	წალამი	0.5	0.5	თვითონ ამუშავებს	პირადი მოხმარების თვის და კიდევ საჩუქრად	კი
13	ნუგზარი ქაქალაშვილი	ყვარელი	2	ვენახი	წალამი		0	300	პირადი გამოყენებისთვის	კი
14	დავით მირზიკაშვილი	ყვარელი	2.5	ვენახი	წალამი	1.3	1.3	400	პირადი გამოყენებისთვის	კი
15	დათო ხაჩოშვილი	ყვარელი	2	ვენახი	წალამი	3	3	300	პირადი გამოყენებისთვის ან წვავს თუ ბევრია	კი
16	ლევან ღუჭაშვილი	ყვარელი	3	ვენახი	წალამი	6	6	500	წვავს ადგილზე	კი
17	ტარიელ გრაციაშვილი	ყვარელი	1	ვენახი	წალამი	0.5	0.5	თვითონ ამუშავებს და თანხა არ უჯდება	პირადი გამოყენებისთვის	კი

18	ლევან კურტანიძე	ყვარელი	2	ვენახი	წალამი	0.8	0.8	400	პირადი გამოყენებისთვის, დაახლოებით გამოდის 100 კონა და თვითონვე იყენებს	კი
19	ლევან კოკორაშვილი	ყვარელი	1	ვენახი	წალამი	40მ3	3–4	თვითონ ამუშავებს და თანხა არ უჯდება	წვავს ადგილზე	კი
20	ნუგზარი კახაშვილი	ყვარელი	3	ვენახი	წალამი	3 მანქანა	2.5	20	პირადი მოხმარების თვის	კი
21	ალექსი გიგილოშვილი	ყვარელი	1.5	ვენახი	წალამი	8მ3	1.2	200	ნარჩენის 90% წვავს, 10% ინახვას პირადი გამოყენებისთვის (სამწვადის თვის)	კი
22	ბაწელაშვილი გივი	გურჯაანი	11	ვენახი	წალამი	5 მანქანა („გაზიკი“)	38.5	400 ლარი	ყიდის, კონაში უხდიან 0,40 ლარი	კი, თანახმაა
23	იოსები ნატროშვილი	გურჯაანი	10	ვენახი	წალამი	ვენახი - 60-80 მ3	35	ვენახი - 50-100 ლარი (ჰა)	წვავენ, ძალიან ცოტას იყენებენ პირადად	კი, თანახმაა
			9	ხილი	ანასხლავი	ბაღი - 10 მ3	31.5	ბაღი - 150-200 ლარი (ჰა)		
24	გიორგაძე მიხეილი	გურჯაანი	14	ვენახი	წალამი	700-800 კონა	49	500-600ლარამდე	პირადად იყენებს - აქვს ღვინის მარნის მუზეუმი და იქ სტუმრებს უწვავს მწვადს წალამზე	არა

25	ზაზა ნაპირელი	გურჯაანი	1.8	ვენახი	წალამი	3-5 მანქანა მაინც („გაზიკი“)	6.3	200 ლარამდე	ძალიან ცოტას იყენებენ პირადად, დანარჩენს წვავენ.	კი, თანახმაა
			1.7	ხილი						
26	ნელი ბაცანაძე	გურჯაანი	5	ვენახი	წალამი	10-12 მანქანა („გაზიკი“)	17.5	თვითონ გამოაქვს და უკდება მარტო საწვავი 20 ლიტ დიზელი	თვითონ მოიხმარს, აქვს საკუთარი საცხობი და შეშად იყენებს	კი, თანახმაა თანხის სანაცვლოდ
			2	ხილი	ანასხლავი					
27	გიორგი მათიაშვილი	გურჯაანი	10	ვენახი	წალამი	20 მანქანა („გაზიკი“)	35	200 ლარი	ადგილზე წვავს	კი, თანახმაა
28	გივი თავთეტრიშვილი	გურჯაანი	9	ვენახი	წალამი	60-80 მ3	31.5	ვენახი - 360 ლარი; ხეხილი - 800-900 ლარი	პირადი მოხმარების თვის, უმეტესობას წვავენ	კი თანახმაა
			6	ხილი	ანასხლავი					
29	გიორგაძე მიხეილი	გურჯაანი	14	ვენახი	წალამი	700-800 კონა	49	500-600ლარამდე	პირადად იყენებს - აქვს ღვინის მარნის მუზეუმი და იქ სტუმრებს უწვავს მწვადს წალამზე	არა

30	გოზალი შვილი ლევანი	გურჯაანი	11	ვენახი	წალამი	1000 კონა	38.5	1000ლარამდე	ადგილზე წვავს	კი, თუ თვითონ გამოიტანენ ვენახიდან უფასოდ მისცემს, თუ გამოტანილს წაიღებენ მაში გამოტანის საფასური მაინც რომ გადაიხადონ
31	ჯანიაშვილი გურამი	გურჯაანი	11	ვენახი	წალამი	60-70 მ3	38.5	1000-2000 ლარამდე	ძალიან ცოტას იყებნებ პირადად, დანარჩენს წვავენ.	კი, აჩუქებს კიდეც
			1	ხილი	ანასხლავი		3.5			
32	თამრიკო დიღმელი	შვილი	გურჯაანი	4	ვენახი	წალამი	10 მანქანა მაინც („გაზიკი“)	14	გასხვლა და გამოტანა ერთი რიგის ჯდება 6-10 ლარი (1 ჰა-40 რიგი)	ძალიან ცოტას იყებნებ პირადად. მსურველებს ურიგებს და დანარჩენს წვავენ.
33	გოჩა ფანჩვაძე		0.2	ხილი	ანასხლავი		0.7			

34	გიქოშვილი მიხეილი	საგარეჯო	5.5	ვენახი	წალამი	1 ჰა-ზე 80-100 კონა	19.25	300-500 ლარამდე	პირადა მოიხმარას, დანარჩენს წვავენ	კი
			2.5	სახნავი	ბალახი		8.75			
35	მემარნიშვილი მალხაზი	საგარეჯო	12.6	ვენახი	წალამი	1 ჰა-ზე 3-4 ტ.	44.1	600 ლარამდე	წვავს	კი თუ გაიტანს 15 მარტამდე, რომ ხელი არ შეეშალოს
			0.4	ხილი	ანასხლავი		1.4			
36	მურაშვილი როინი	საგარეჯო	5	ვენახი	წალამი	1 ჰა-ზე 100 კონა	17.5	300 ლარამდე	პირადა მოიხმარას, დანარჩენს წვავენ	კი
37	ზურაბ მერიანაშვილი	საგარეჯო	15	ვენახი	წალამი	4-5 ტონა	52.5	ჰექტარზე უჯდება 150 ლარი, ჯამში 2300 ლარი	წვავს	კი
			3	ხილი	ანასხლავი		10.5			
38	როსტომ როსტიაშვილი	საგარეჯო	4	ვენახი	წალამი	1 ჰა-ზე 2 ტ.	14	300-500 ლარამდე	პირადად მოიხმარას, დანარჩენს წვავენ	კი
39	თენგიზ მალასიძე	საგარეჯო	2.2	ვენახი	წალამი	4 მანქანა, 2,5 ტონა	7.7	300-500 ლარამდე	წვავს	კი (უფასოდაც გაატანს თუ თვითონ გამოიტანენ ანუ მყიდველები)
			1.8	ხილი	ანასხლავი		6.3			

40	ბეგიაშვილი გოჩა	საგარეჯო	8	ვენახი	წალამი	2,5 ტონა. 1 კონა 10 კილოგრამამდე, 100 პლანზე 10-15 კონა	28	700 ლარამდე	ადრე წვავდა, ახლა კი ყიდის	კი
41	თედო ჯავახიშვილი	საგარეჯო	6.5	ვენახი	წალამი	42160	22.75	საწვავის თანხა	წვავს	კი
42	თამაზი კევლიშვილი	საგარეჯო	4.5	ვენახი	წალამი	100 კონა	15.75	300 ლარამდე	პირადა მოიხმარას, დანარჩენს წვავენ	კი
			0.5	ხილი	ანასხლავი		1.75			
შიდა ქართლი										
43	კლიმენტი იმერლი შვილი	გორი	6	მსხალი, ვაშლი	ანასხლავი	2 მანქანა/ჰა	21	300	წვავს	კი
44	ნუგზარ ხმიადაშვილი	გორი	3	ვაშლი, ქლიავი	ანასხლავი	3	3		მულჩის სახით იყენებს	არა
45	აკაკი ხმიადაშვილი	გორი	2.1	ვაშლი	ანასხლავი	5	5.25	150	არ იყენებს	კი
46	ია სურამელი	გორი	2	ვაშლი	ანასხლავი	3	3	200	წვავს	კი
47	მერაბ დედანაშვილი	გორი	2	ვაშლი, მსხალი	ანასხლავი		7	200	წვავს	კი
48	ალექსანდრ ანდრონიკაშვილი	გორი	2	ვაშლი	ანასხლავი	2.5–3	2.5–3	200	ყრის, წვავს	კი
49	მერაბ ქუჩუკაშვილი	გორი	10	ვაშლი, მსხალი, ქლიავი	ანასხლავი	30	30		მულჩის სახით იყენებს, დანარჩენს წვავს	კი
50	ლევან ბიძინაშვილი	გორი	15	ვაშლი, ქლიავი,	ანასხლავი	2 მანქანა/ჰა	52.5	300–400	ყრის	კი

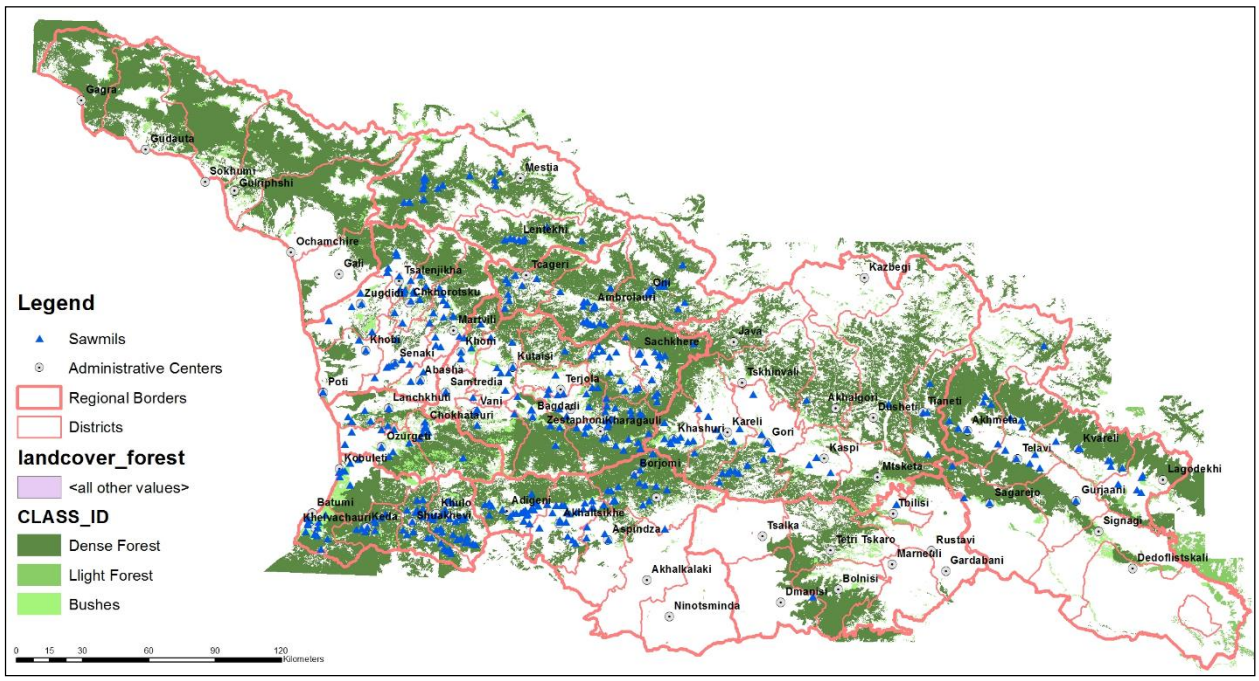
				მსხალი, ატამი						
51	ელდარ თევდორაშვილი	გორი	2.45	ვაშლი, ქლიავი	ანასხლავი	3.5	3.5	300	წვავს	კი
52	ზაზა მირუაშვილი	გორი	11	ვაშლი, ქლიავი, ატამი	ანასხლავი	33	33	საკუთარი მანქანით გააქვს	წვავს	კი
53	აკაკი საგანელიძე	გორი	16	მსხალი, ატამი, ქლიავი, ვაშლი	ანასხლავი	40	40	350	ყრის	კი
54	ნუნუ მურალოვი	გორი	5	ვაშლი, ქლიავი, სიმინდი	ანასხლავი	10–12მ3/ჰა	17.5	არ ვიცი	ყრის და წვავს	კი
55	ანრი ქართველიშვილი	გორი	18	ვაშლი, ქლიავი, ატამი, ტყემალი, ბალი	ანასხლავი		0	300 ლარი/ჰა	ყრის და წვავს	კი
56	იოსებ ფარეხელაშვილი	გორი	6	ვაშლი	ანასხლავი	3	3	200	ყრის	კი
57	ავთანდილ ფარეხელაშვილი	გორი	5,3	ხილი, ბოსტნეული			0			
58	მარინა პეტუაშვილი	გორი	5	ვაშლი, მსხალი	ანასხლავი	3	3	150	ყრის და წვავს	კი
59	შალვა წოწოლაშვილი	გორი	6	ვაშლი	ანასხლავი	10–15მ3	21	200	წვავს	კი
ქვემო ქართლი										
60	ნუნუ სამხარაული	გარდაბანი	20	სიმინდი	ჩალა	1-2 მანქანა	52	200 ლარი	საქონლისთვის	არა
61	რობიზონ ლალიაშვილი	გარდაბანი	49	ხორბალი, სიმინდი	ნამჯა	2 მანანა	127.4	300 ლარი	საქონლისთვის/ნაწილს ყიდის	თუ იყიდის კი

62	გოჩა ჩადუნელი	გარდაბანი	30	ხორბალი, სიმინდი	ჩალა/ნამჯა	1 მანქანა (ურალი)	78	300 ლარი +მუშა 20 ლარი	საქონლისთვის	გაყიდის
63	გიორგი გოგოჭური	გარდაბანი	17	სიმინდი/ხორბალი	ჩალა/ნამჯა	150 ტუკი 1 ჰა. 1 ტუკი =20-22 კგ	44.2	300-500 ლარი	საქონლისთვის, ნაწილი ჩახვნა	გაყიდის ნაწილს
64	ალექსანდრე ტაბატაძე	გარდაბანი	21	სიმინდი/ხორბალი	ჩალა/ნამჯა	1 ან 2 მანქანა, მანქანა ზე იდება დაახლოებით 2 ცალი	54.6	300-400 ლარი	ნაწილს ყიდის	კი
65	გიორგი გელაშვილი	გარდაბანი	21	სიმინდი/ხორბალი	ჩალა/ნამჯა	130 პრესი. თითო პრესი =17-20 კგ.	54.6	250-300 ლარი	ნაწილი საქონლისთვის, ნაწილს ყიდის	კი
66	ლევან ადეიშვილი	გარდაბანი	85	სიმინდი/ხორბალი	ჩალა/ნამჯა	120 პეწსი 1 ჰა. ზე. პრესი =18-20 კგ.	221	700 ლარი	საქონლის საკვებად, დანარჩენს ჩახნავს	არა
67	დავით მეფარიშვილი	გარდაბანი	130	სიმინდი/ხორბალი	ჩალა/ნამჯა	150 ტუკი ჰექტარზე - 3 ტონა დაახოებით.	338	400 ლარი	საქონლისთვის	არა
68	პაატა ხუროშვილი	გარდაბანი	45	ხორბალი, სიმინდი	ჩალა/ნამჯა	150 პრესი 1 ჰა.	117	400-500 ლარი	საქონლისთვის, ნაწილს ტოვებს მინდორში	არა
69	შოთა ბიწაზე	გარდაბანი	30	ქერი/სიმინდი	ჩალა	2 მანქანა 1.5 ტონიანი	78	300 ლარი	ჩახნავს და ყიდის.	გაყიდის

70	ალადინ იმალიევი	გარდაბანი	50	ხორბალი /სიმინდი	ჩალა/ ნამჯა	150-160 პრესი 1 პრესი = 20 კგ.	130	300-400 ლარი	ყიდის	გაყიდის
71	შოთა წიკლაური	გარდაბანი	78	სიმინდი, ხორბალი, ქერი	ჩალა/ ნამჯა	140-160 პრესი	202.8	300-500 ლარი	ჩახნავს, ნაწილს ყიდის	არა

Annex 5 - Field Survey of Potential for Biomass Use for Energy in Georgia - GIS Component

One of the main components of field survey of Potential for Biomass Use for Energy in Georgia was targeting Sawmills operation all over the Georgia. The questionnaire survey was conducted to study available residue resources, potential annual accumulation and, accessibility and other related parameters. Taking into account that spatial distribution of sawmills, respective wood resources, accessibility, etc, would play a significant role – GIS was selected as tool for data collection, visualization and analysis.



Pic 24. Distribution of sawmills in Georgia vs forest coverage and administrative division

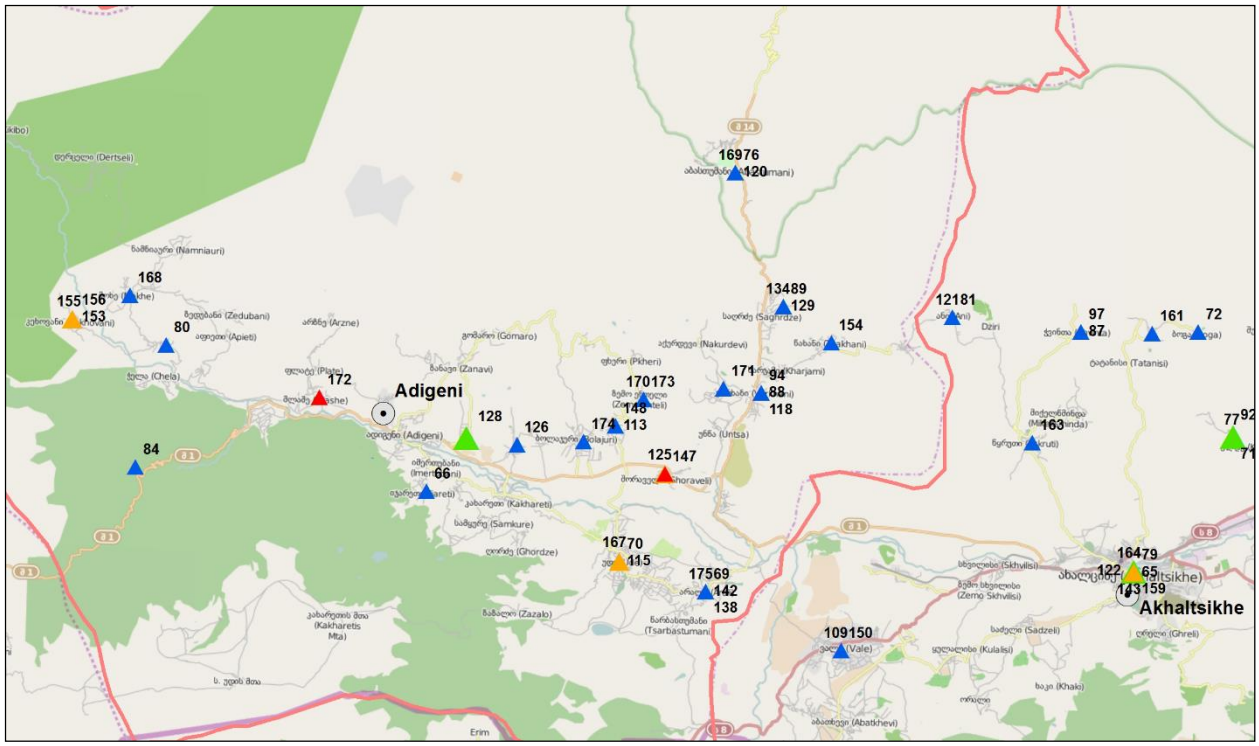
GIS component of Survey aims obtaining the precise geographic coordinates of sawmills location in general and creation of the geo-database with the structure suitable for further geospatial analysis of collected data. Format of the Survey GIS component generally corresponds to the following concept: sawmills can be represented as discrete set of points reflecting their so-called legal addresses, used to

register the legal entity, mainly on the settlement level, later on to be replaced by the actual business operation address- GPS coordinate measured at the exact location of sawmill and its residue storage site.

Initially the complete database of sawmills, Provided by NFA was analyzed to select respondents for survey. Database was linked in GIS with the database of settlements in Georgia, to visualize their spatial distribution. After final selection of respondents to be questioned, survey was divided in several waves according to Geographical locations, special maps of sawmill locations were prepared featuring with green color those respondents who answered the phone and agreed to fill questionnaire and with orange potential locations to be questioned.

Table 2: ***Survey Waves by dates and regions***

#	Survey Wave	Num of Quest.
1	150213 Kartli 1	2
2	150214-15 Imereti 1	9
3	150220 Kartli 2	2
4	150221-22 Kakheti	6
5	150221-22 Samtskhe-Javakheti	8
6	150309-10 Senaki-Martvili	9
7	150322-23 Imereti 2	8
8	150324-26 Racha	11
9	150325-26 Tsalenjikha-Zugdidi	8
10	150508-10 Svaneti	6
11	150515-17 Achara	9



Pic. 25 Maps of sawmill locations for field survey with green color those respondents who answered the phone and agreed to fill questionnaire and with orange potential locations to be questioned. Red colors show refusals.

The Survey results were stored in separate excel sheets with unique number, which allows to easily find a questionnaire for the selected sawmill on the map. In addition to unique ID numbers linking the GIS database and actual questionnaires, Three main parameters were taken from field survey results and incorporated into GIS database: Volume of residue on site, Volume of potential annual residue for each questioned sawmill and accessibility of location. Based on these parameters thematic maps by region were compiled visualizing all these parameters for questioned sawmills (See Annex 1).

The above described concept corresponds to one major target – *multi-functionality*, which means that the design should be flexible enough for the future possible analysis of Survey geo-database in the GIS environment and its further enlargement with new data. For instance, the sawmill operation locations can be represented as being involved in the broader network of value transportation or exchange, which basically represents the road network including railroad or other means of transportation, is limited by natural, i.e. river, mountain ridge, etc., and administrative boundaries. Another sphere of analysis could be financial side of business operation. In this case the financial network of Georgia with the distribution of banks and other financial institutions should be considered.