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Projecting Circular Economy in rural areas and its impact on sustainable development principles, a case study from Kosovo

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ABBREVIATIONS

AGB	Aboveground biomass
CAP	Common Agriculture Policies
CE	Circular Economy
CHP	Combined Heat and Power
CSMs	Crop Surface Models
E.U	European Union
Eu	Euclid (winter wheat cultivar)
Ex	Exotic (winter wheat cultivar)
FGT	Foster, Greer, and Thorbecke
GAEC	Good Agricultural and Environmental Condition
GFCE	Gross Final Consumption of Energy
GHG	Green House Gases
ILUC	Indirect Land-Use Change
NOx	Nitrogen Oxides
RES	Renewable Energy Sources
RES- E	Renewable Energy Sources from Electricity
RES- H&C	Renewable Energy Sources from Heating and Cooling
RES- T	Renewable Energy Sources from Transport
SFM	Structure-from-Motion
SGB	Second-Generation Bio-fuels
SME	Small and Medium Enterprises
SOC	Soil Organic Carbon
UAVs	Unmanned Aerial Vehicles
UAS	Unmanned Aerial Systems
Vu	Vulcan (winter wheat cultivar)

Explanation of the terms

Total Biomass (wheat plant which is cut 2 cm above the ground with straw, leafs, chaff and seeds)

Total Dry Biomass (wheat plant which is cut 2 cm above the ground, with straw, leafs and chaff without seeds)

Dry biomass (wheat plant which is cut 15 cm above the ground, with straw, leafs and chaff without seeds)

Collectable straw (wheat plant which is cut 15 cm above the ground, without chaff, stubble and seeds).

Total Straw (wheat plant which is cut 2 cm above the ground, without chaff, stubble and seeds)

1 INTRODUCTION

According to BIILGEN ET AL. (2007) the only natural, renewable carbon resource known that is large enough to be used as a substitute for fossil fuels is biomass. For biomass to be effective at reducing greenhouse gas emissions, it must be produced in a sustainable way (EUROPEAN COMMISSION, 2014). Pellet it considered as a source of renewable energy for heating and electricity, however as a result of frequent reports (FAZEKAS & TUERK, 2016; IEAB, 2017; NRDC, 2020; TIMILSINA & MEVEL, 2013; WAL, 2021) that the production of pellets from wood is not sustainable and causes deforestation which is expressed mainly in developing countries, authors (FAZEKAS & TUERK, 2016; PERLACK, 2005) required to give importance to the use of agricultural residues (dry matter) as renewable energy for heating, in this case it would bring extra income to farmers and also reduce deforestation (EUROPEAN COMMISSION,. 2018). Overall, wheat straw contributes most to the total share of primary agricultural residues (dry matter) which is also the main contributor of biomass burning in open fields(EUROPEAN COMMIAAION., 2017; YEVICH & LOGAN, 2003). Regarding to Europe, wheat straw is the most significant potential source of feedstock for Second Generation Biofuels production (SCARLAT ET AL., 2010). Furthermore, E.U. policy encourages the use of crop residues instead of dedicated crops to reduce land-use by non-food crops (SUARDI ET AL., 2020). Many authors give evidence about biomass loss, air pollution deriving from on-field straw burning, and land degradation (CHALCO VERA ET AL., 2017; NGUYEN & NGUYEN, 2019; ZUO ET AL., 2020). One of the tools that help in this transition is Circular Economy. The Circular Economy concept is based on recovering onsite resources that are still circulating (overproduction, waste) instead of importing them from abroad (DONIA ET AL., 2018). According to ENEL (2008), circular economy is a strategic ally of sustainable development. Working on the circular economy means working on the majority of SDGs (KRUCHTEN & EIJK 2020). Using biomass residues for energy would be a nonfarm generating activity for farmers, and besides reducing poverty, it is also environmentally friendly (KUROWSKA ET AL., 2014; ROZBICKA & SZENT-IVÁNYI, 2020; YMERI ET AL., 2020). Selling straw is considered as extra income (MINAS ET AL., 2020) for example based on the study of MARKS-BIELSKA ET AL., (2019), the amount that farmers would generate from selling straw would be 4.3 million euro, and 664 dollar per ha due to bioethanol from straw (BHATTACHARYYA ET AL., 2021). SCHOR, (2017) highlights that C.E. may increase inequalities due to disadvantages that low-income, less-educated people have regarding access. GRADZIUK ET AL. (2020) states that small farms reduce substantially the possibility of using high-performance, large-sized presses, which in turn determines the economic feasibility of biomass supply. In line with this statements are also authors who reported that extra income can increase inequality (IQBAL ET AL., 2018; KMOCH ET AL., 2018; MAT ET AL., 2012; WOLDEHANNA & OSKAM, 2000).

According to EUROPEAN COMMISSION (2017A), 'circularisation' could cause economic and social stress unless properly analyzed before implementation. Thus KIRCHHERR ET AL. (2017) suggest that those who propose C.E. may be well-advised to state social equity as one of its design variables. When it comes to environmental aspect and biomass capacity, there are different factors that impact the amount of straw including the type of crops, crop variety, crop rotation, agricultural management practices (e.g., tillage), climate, and physical characteristics of the soil, type of harvest, fertilizers (BATIDZIRAI ET AL., 2016; DONALDSON ET AL., 2001; GALLAGHER & BISCOE, 1978; LARSEN ET AL., 2012; LINDEN ET AL., 2000; PELTONEN-SAINIO ET AL., 2008; SKØTT, 2011; YEVICH & LOGAN, 2003) thus, there are no criteria on straw removal except "loss of soil fertility if too much straw is removed" (ELBERSEN ET AL., 2010; GLITHERO, RAMSDEN, ET AL., 2013). Besides its importance there are authors (TOWNSEND ET AL., 2017) that proclaimed that usually biomass residues are overestimated this is because in general, different studies discussed the amount of wheat residues that are available to use for energy purposes, without agronomic measurement, most of them found this amount based on coefficients suggested from literature review (CAI ET AL., 2008; KARAJ ET AL., 2010; KUMAR ET AL., 2015; LANFRANCHI, 2012; MARKS-BIELSKA ET AL., 2019; SAHITI ET AL., 2015; YANLI ET AL., 2010; ZHANG ET AL., 2019; EZEALIGU AT AL., 2021). While, according to GIANNOCCARO (2017) In the economics of biomass, it is possible to apply the method that considers the willingness of farmers to supply which is critical in the early stages of commercialization of new technologies and industry development (ALTMAN ET AL., 2015; GAUS ET AL., 2013; GLITHERO, RAMSDEN, ET AL., 2013; PANNELL ET AL., 2006; TOWNSEND ET AL., 2017; ZYADIN ET AL., 2019). A comparison between these approaches and the convention alone could lead to new interdisciplinary collaborations, and this type of data could be used as a basis for further studies. Thus the first aim of this study is to recognize the impact of non-farm income on farmer's wellbeing regarding poverty and inequality, to distinguish farmers' attitudes toward a new biomass market from wheat straw as a source of energy and the third one to measure the potential capacity of wheat residues based on agronomic assessment and willingness of farmers to sell straw, these are vital to design and present economic and policy incentives successfully.

1.1 Research Procedure – Flow Chart

Figure 1 presents a flowchart which is a graphical representation of the research process.

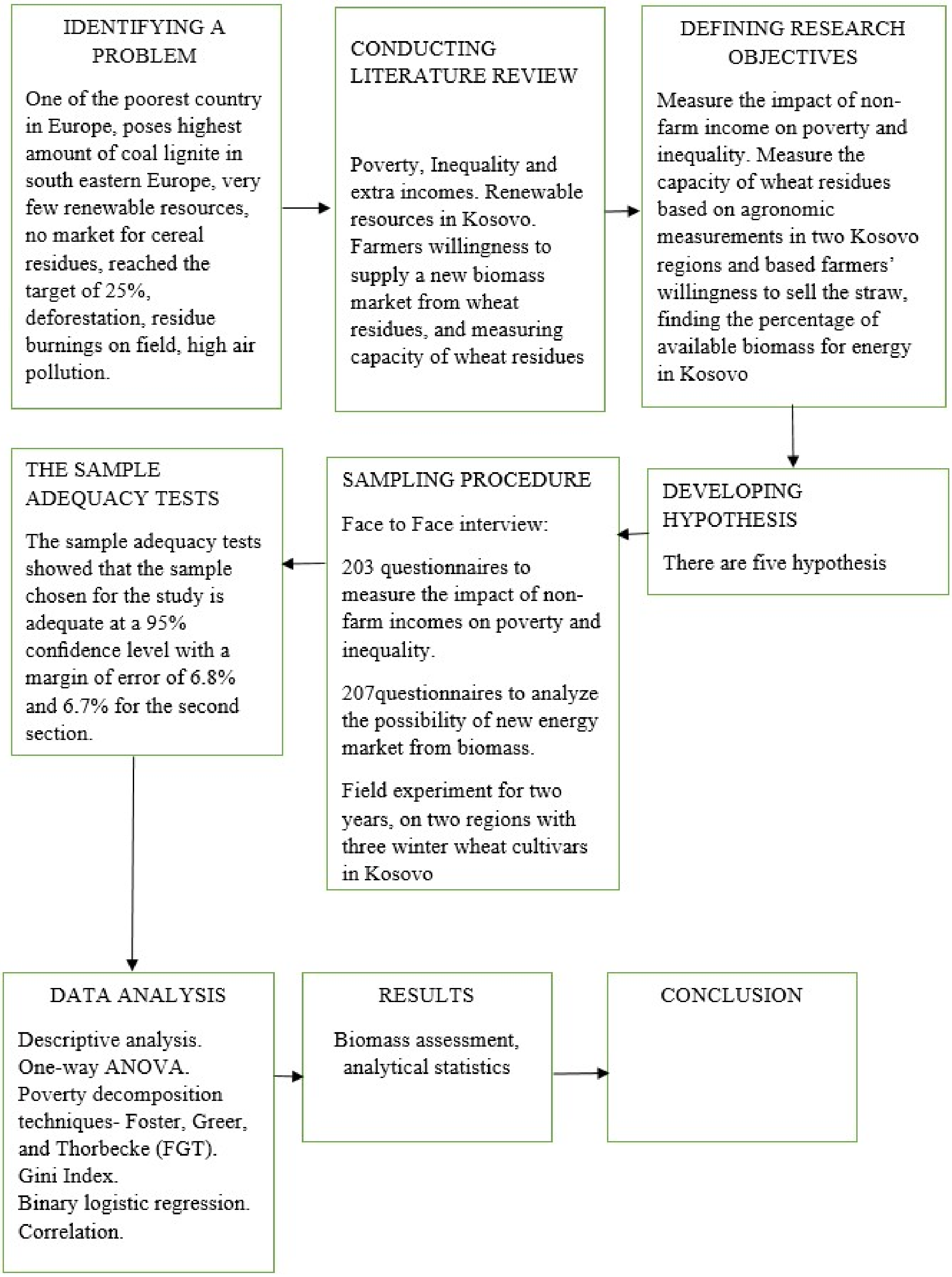


Figure 1. Research Procedure
Source: Author's own construction

1.2 Problem Statement and Justification

There are many reports on deforestation due to wood use for pellet production or traditional use for heating purposes especially in developing countries. The reports show how burning wood as "renewable bioenergy" (through pellets) is not as sustainable as the EU's climate and energy policies assert it to be (FAZEKAS & TUERK, 2016; IEAB, 2017; NRDC, 2020; TIMILSINA & MEVEL, 2013; WAL, 2021), thus according to FAZEKAS & TUERK (2016), increasing the use of biomass (example agricultural by-products) could be necessary from both an environmental and a climate protection perspective. Still, in many cases, this is not a part of the current practice. Typically, in developing countries, a large amount of agricultural waste suitable for energy use remains unexploited, remaining on the arable land or being burned in the field (MCNULTY & GRACE, 2009; NIKOLOV, 2011; Y. WANG ET AL., 2010). Complicating matters is the fact that some countries have significant fossil energy reserves. This is also the case in Kosovo, which has the largest coal (lignite) reserves in southeastern Europe (C.E.E.B.N. 2019). An important question is how polluting, and non-climate-friendly fossil fuels are to be replaced when they are available cheaply and in large quantities, and in the same time how can we reduce deforestation when 85-100% of households use wood for heating purposes while other sources of heating are electricity, natural gas, heavy oil and coal (KABASHI ET AL., 2016). Kosovo's G.D.P. per capita is among the lowest in Europe, with high poverty rate and unlike many countries in the region, it has not changed over time (WORLD BANK, 2007, 2017). Based on the data from Eurostat (EUROSTAT 2019; M.E.E. 2021) regarding Kosovo, when it comes to energy for electricity only 5.14% comes from renewable sources, which means that electricity from coal is 94.86%, it is one of the highest shares of energy from coal compared to neighbouring countries see: (ITA, 2020; KISS & PETKOVIČ, 2015; NIKOLAKAKIS ET AL., 2019) and it is monopoly (HOXHA ET AL., 2018). The air pollution exceeds the allowed average emission values (particulates 9-16 times higher and NOx 34-62%) (DRESHAJ ET AL., 2017). The obligatory general target of partaking in energy from renewable energy in G.F.C.E. of energy in 2020 was 25%, defined by the Decision of the Council of Ministers of the Community of Energy D/2012/04/MC-EnC for implementation of the Directory 2009/28/E.C., Kosovo reached the target of 25.69%, and made a voluntary target of 29.47%, however from the achieved target from overall G.F.C.E, 23.89% is from biomass for heating purposes, and 1.8% from renewable electricity (EUROSTAT 2019; M.E.E. 2021). There are also reports that this biomass is not sustainable due to the high amount and illegal logging, except these, there are several residue burnings (wheat, corn etc.) into the opening fields (M.E.D. 2013;W.B.I.F. 2017;TOMTER ET AL., 2013), which are associated with forest burnings and air pollution. According to several authors (HORVATH ET AL., 2018; HORVÁTH & FOGARASSY, 2017), emission rates can significantly decrease and improve the system's sustainability if circular system elements like renewable energy resources are integrated into the planning processes. When it comes to Circular Economy and renewable energy several authors claim that social equity is usually absent on the C.E. concept, including unequal distribution of wealth, income, and labour conditions. Selling straw is considered as an extra nonfarm income. However, there are reports where nonfarm incomes cause inequality between farmer's households (IQBAL ET AL., 2018; KMOCH ET AL., 2018; MAT ET AL., 2012; WOLDEHANNA & OSKAM, 2000). Thus in the first part of our study, we analyzed if nonfarm incomes create inequality in Kosovo's case. Our second purpose was to specify the amount of straw available for energy use; when it comes to this topic, two reasons require attention: The first reason is described by TOWNSEND ET AL. (2017), who states that biomass is overestimated because of the variation with cultivar and location-specific factors. The ratios must be calculated for individual cultivars and locations to predict straw yield from grain yield accurately. While the second reason is described by GLITHERO ET AL. (2013*a*), who stated that straw availability might also be overestimated as calculations often assume that all farmers who can sustainably supply straw will supply that straw, whereas, in reality, many farmers are unwilling to do so because of, for example, concerns about negative soil impacts and potential delays in planting subsequent crops. Studies in social science fields usually can overestimate the amount of straw caused by missing the part of agronomic measurement or the willingness of farmers to sell straw. Our study gives a clear picture regarding how nonfarm incomes will impact rural households' wellbeing and the biomass capacity of Kosovo for bioenergy based on farmers' willingness to sell straw and agronomic measurement.

1.3 Significance of the Study

According to CRAMER (2017), all forms of product reuse potentially form a huge economic motor in a circular economy and, hence, more jobs. Implementing the 'circular economy' across the agro-food sector might indirectly play an important role in income diversification. The study will analyze how nonfarm incomes will impact farmers' wellbeing by using the Gini index for measuring inequality and F.G.B. indexes for poverty. In this way, the study will suggest adopting suitable rural policies to address income distribution inequality. The extra income resulting from the sale of straw prompts an increase in farmers income and in the production of wheat, which would be a positive indicator, as until now, the total domestic production of wheat in Kosovo covers 57% of local consumption needs and the rest is covered by import(M.A.F.R.D. 2020). Using straw for energy purposes would also reduce straw burnings in open fields which is one of the main causes of forest fires (NIKOLOV, 2011) and air pollution (BHATTACHARYYA ET AL., 2021; MINAS ET AL., 2020). Thus, this study provides guidance on the level of incentives that may be paid to farmers to discourage open-field straw burning.

Previous researches have paid little attention to the producer conditions for available waste biomass sales. Studies have not examined the attitudes of farmers' sales or under what conditions they are willing to sell a larger proportion of straw, of course, in such a way that they also meet the needs of animal husbandry, nutrients, and carbon supply. Using binary logistics regression and descriptive statistics not yet used in previous research, we analyzed the factors that influence farmers' willingness to sell more or less than 50% of straw, sales barriers, and incentives.

Regarding the use of wheat straw for bioenergy, there are no criteria on straw removal except "Loss of soil fertility if too much straw is removed" (ELBERSEN ET AL., 2010); based on this, there are different studies that can overestimate the amount of wheat straw for energy purposes as various studies discussed the amount of wheat residues that are available to use for energy purposes based on suggestions from literature review and statistical calculation (CAI ET AL., 2008; KARAJ ET AL., 2010; KUMAR ET AL., 2015; LANFRANCHI, 2012; MARKS-BIELSKA ET AL., 2019; SAHITI ET AL., 2015; YANLI ET AL., 2010; ZHANG ET AL., 2019; EZEALIGU AT AL., 2021). These analyses make our study the first one that assesses wheat biomass, based on agronomic measurements and willingness to sell straw, taking into consideration the sustainability rate of straw removal or the chain which begins from finding the report straw to grain, collectable amount of straw and willingness to sell it for energy purposes. Our study finds the percentage of straw that can be used for energy purposes from the total dry biomass and collectable straw, considering the percentage of the willingness of farmers to sell straw. The study also provides differences between the three most used cultivars during two years of experiment in two regions of Kosovo with different climatic conditions. This knowledge is vital to successfully design and present economic incentives and policy initiatives at the governmental level. The results provide valuable information for government and businesses to determine the feasibility of commencing new biofuel enterprises or other activities utilizing crop straws. To international literature our results will give an indication of how much biomass can be used taking into account the agro-technical measurement and the willingness of the farmer to sell straw, this coefficient can also be used by other papers.

2 OBJECTIVES TO ACHIEVE

The motive for this study is to reduce deforestation, straw burning in fields that are associated with forest burnings through the use of straw as renewable energy for heating purposes. The new energy biomass market would also bring extra income to the farmers and reduce air pollution. Additionally, our study aims to provide scientific information to local/national organizations as well as on governmental level, regarding the capacity of wheat residues from three most used cultivars in Kosovo, which would be the first step (regarding biomass sources-except wood) that would help in the transition from coal to sustainable biomass use. Regarding international literature, the study's objective is to give the exact values of straw measurement by combining agronomic measures with the willingness of farmers to sell straw, based on the sustainable removal rate of straw. The other objective of this study is to understand how non-farm income affects the welfare and inter household income inequality in Kosovo's case.

Specific Objectives

1. Analyze the impact of off-farm income on poverty and inequality.
2. Analyze which socio-economic factors determine the willingness of farmers to sell straw on higher amounts.
3. Analyze practices, barriers and incentives toward a new market with straw biomass.
4. To find out correlation between wheat parameters in order to better predict the amount of straw, and assess the ratio between total dry biomass to seed, straw for energy purposes to total dry biomass and straw for energy purposes to collectable straw.

2.1.1.1 Scientific Research Model

Degradation of the natural environment and the energy crisis are two vital issues for sustainable development worldwide (NI ET AL., 2006). Sustainable development implies creating environmental quality, economic prosperity and social equity for current and future generations(KIRCHHERR ET AL., 2017). The implementation of the Sustainable Development Strategy through the Sustainable Development Goals 2015-2030 needs to take into consideration the EU' package from December 2015 concerning the achievement of the Circular Economy under the vision of the 3R - Recycle, Reuse, Reduce (CIANI ET AL., 2016). According to ENEL (2008), circular economy is a strategic ally of sustainable development. Working on the circular economy means working on the majority of SDGs, not as a cost item but as a business model (KRUCHTEN & EIJK, 2020). It is fundamental to highlight that the Circular Economy means changing people habits, mentalities (BELC ET AL., 2019). C.E. must promote loops when socially desirable and efficient(ANDERSEN, 2007).

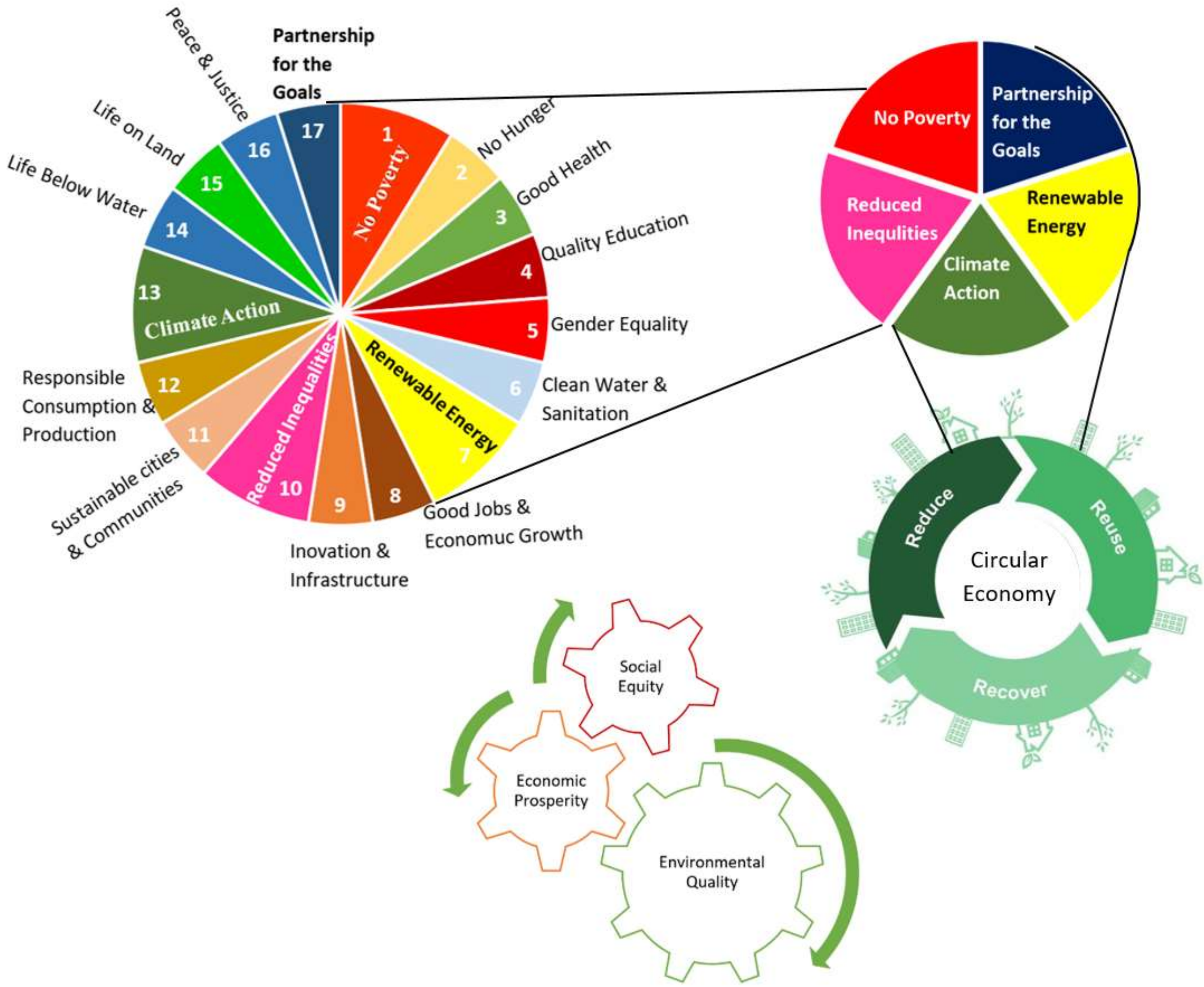
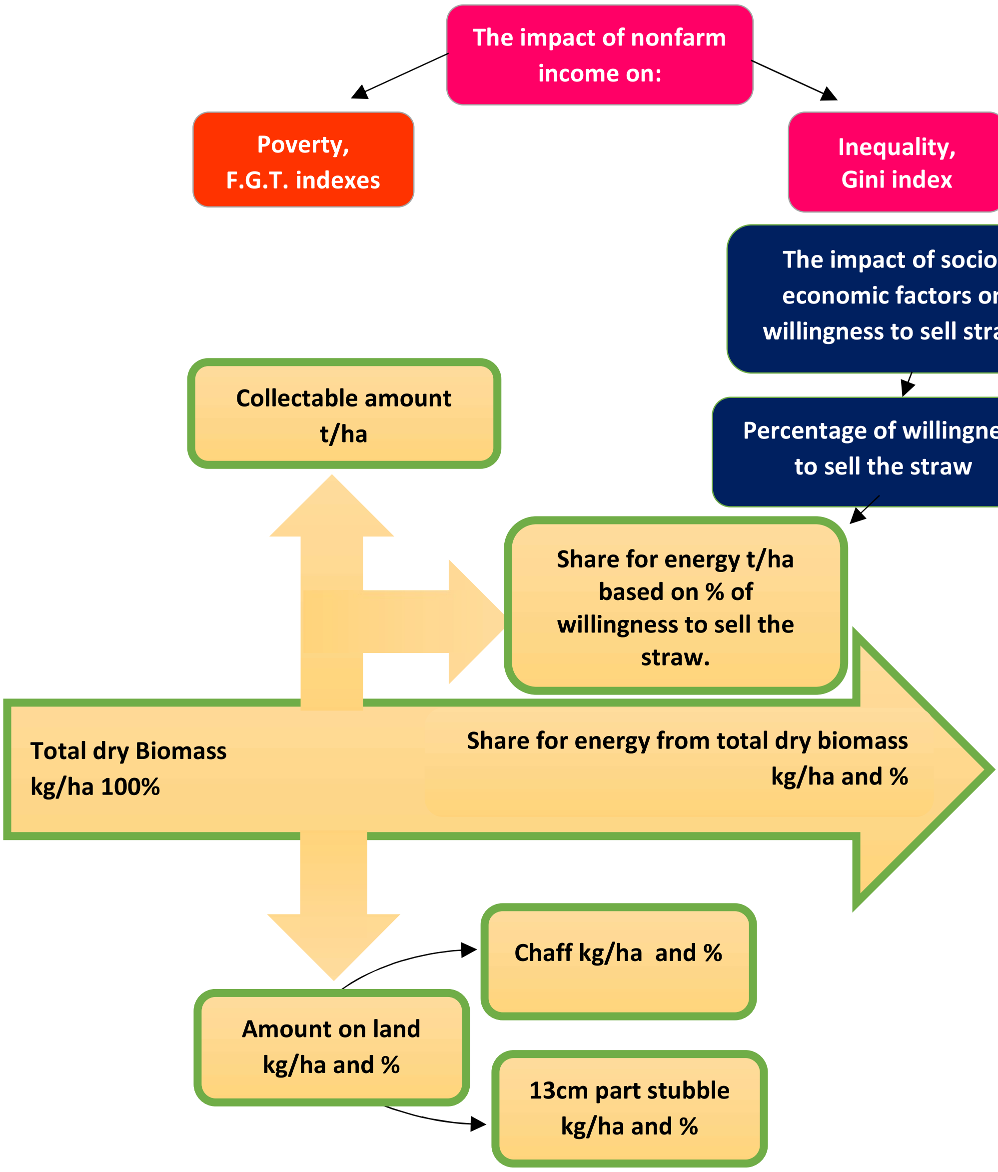


Figure 2. Conceptual framework model; Sustainable Development goals in terms of Circular Economy.

Source: Author's own construction based on UNITED NATION,(2015) assembly and EUROPEAN COMMISSION (2015)

From all key components of sustainable development principles, less than 1% of literature on circular economy speak of equity or equality, human attitudes and only ca. 1% covers poverty (VELENTURF & PURNELL, 2021). Based on the study of SCHROEDER ET AL. (2019) circular economy can also contribute to poverty, reduced inequlities, renewable energy and climate action. Figure 2. Represents the relationship between sustainable development goals and circular economy, which both have common principles; Environmental Quality, Economic Prosperity and Social Equity. From the total seventeen goals of sustainable development, the study analyzes these SDGs in Circular Economy perspective: SDG (1) No poverty, SDG (10) Reduced Inequalities, SDG (7) Renewable Energy, SDG (13) Climate action and SDG (17) Partnership for the Goals. The study aim to provide scientific information regarding to povery and inequality amog rural hoseholds in Kosovo, and the impact that extra incomes have on these (related to: SDG 1 and 10). According to KIRCHHERR ET AL. (2017) the dimension of social equity has to do with how the Circular Economy aims to protect, transform, strengthen and develop society, human wellbeing and jobs. Furthermore the study aims to measure the capacity of biomass residues from wheat as a source of renewable energy (SDG 7) based on circular pillar "Recover", regarding to climate action (SDG 13) the studys' aim is to reduce burnings of wheat residues into open fiels and reduce deforestation by using agriculture residues as renewable energy at the same time fulfilling the renewable energy targets, while our partnership for the goals (SDG 17) in the study will be farmers and their willingness to participate into a new market for renewable energy production. According KRUCHTEN AND EIJK (2020) the transition to the circular economy requires systemic change and asks for collaboration. Below is described the flow of the model with specific analysis. The figure 3 explains the research model of this study;



Face to face interview, the year 2017, sample 203

Face to face interview, the year 2019, sample 206,

Two years experiment 2018-2019 and 2019-2020 in two regions of Kosovo, three winter wheat cultivars.

Figure 3. Research Model
Source: Author's own construction

Regarding experiment, different authors suggest a sustainable removal rate of straw residues from land between 33-60% (DAIOGLOU ET AL., 2016; SPÖTTLE ET AL., 2013) and available biomass for energy purposes 25-62% (ALAKANGAS, 2011; CAI ET AL., 2008; KARAJ ET AL., 2010; WEISER ET AL., 2014; YANLI ET AL., 2010). However, according to TOWNSEND ET AL. (2017), there is uncertainty regarding the amount of straw chopped, incorporated and used, and, taken together with the uncertainty regarding the amount of straw that can be sustainably harvested, it is unclear how much straw is available for bioenergy production. While, according to GAUS ET AL. (2013) and GLITHERO ET AL. (2013*a*), farmers' decision-making determines the amount of straw available on the market. Thus this study takes into account the amount of straw that can be produced in sustainable way and based on willingness of farmers to sell it.

2.2 Research Questions and Hypothesis

The main research questions of the paper are: what is the biomass capacity which can be used for energy purposes in Kosovo and what are farmers' attitudes regarding a new straw market? How will the extra incomes impact the wellbeing of rural households?

H1: There is a significant difference in nonfarm incomes based on household income

H2: There is a significant difference in nonfarm income between the engagement time of farmers in agriculture

H3: The presence of animals and the experience in selling straw has impact on farmers' willingness to sell straw

H4: Socio-economic factors have a significant effect on farmers' willingness to sell straw

H5: There is a significant difference regarding the amount of residues based on cultivars, regions, years.

3 LITERATURE REVIEW

3.1 Biomass Energy and Deforestation

Biomass can be used for heating, electricity generation, and transport fuels (EUROPEAN COMMISSION, 2014). According to BIILGEN ET AL. (2007) all forms of biomass utilization can be considered part of a closed carbon cycle. Biomass is the dominant renewable energy source today, as around two-thirds of current renewable energy production in the EU-28, expressed in terms of final energy, is produced from solid, gaseous, and liquid biomass sources (EUROPEAN COMMISSION., 2017). Solid biomass represents the largest share at E.U. level (90.8 Mtoe gross inland renewable energy consumption), followed by liquid biomass (14.4 Mtoe), biogas (13.5 Mtoe), and the renewable part of Municipal Solid Waste (9.1 Mtoe) (PERLACK 2005; EUROPEAN COMMISSION., 2017). The leading application concerning biomass for energy is heat, representing around ¾ of total bioenergy and its main end-use in the residential sector. Electricity from biomass was second in the past, but in recent years biofuels for transport purposes took over – and it is expected that this will remain so in the (near) future (PERLACK 2005; GLITHERO ET AL. 2013*A*; EUROPEAN COMMISSION., 2017)**.** On the other hand, fuel-wood consumption is a determining socioeconomic factor for deforestation and degradation (ULLAH ET AL., 2021), which is a major ecological problem in most developing countries. However, energy transitions involving decreased reliance on traditional wood fuels and increased use of forest-derived modern fuels (e.g. pellets, biofuel) are generally synergistic with achieving other SDGs (KATILA ET AL., 2019). According to KLINE ET AL. (2021) production of woody pellets in US, to displace coal for energy in Europe generate positive effects on different sustainable development goals, however its weaknesses are associated with potential impacts on air, water, and biodiversity that arise if the resource base and harvest activities are improperly managed. There are many reports on deforestation due to wood use for pellet production, for example according to Natural Resources Defense Council (NRDC, 2020) in Southeastern United States, trees are cut down from forests to produce wood pellets which then are exported and burned as fuel in European power plants. They state that this biomass energy damages the climate, air, forests, and communities. According to different authors (FAZEKAS & TUERK, 2016; TIMILSINA & MEVEL, 2013) it is debatable that many biofuels may actually emit more GHG than fossil fuels due to deforestation and land use change. In addition, deforestation linked to biofuels in Europe has led to biodiversity loss, land conflict, labor issues, and indigenous right issues in places as far away as Indonesia, Brazil, and Tanzania. Furthermore, new research by the Centre for Research on Multinational Corporations (SOMO), commissioned by Greenpeace Netherlands, shows how burning wood as "renewable bioenergy" is not as sustainable as the EU's climate and energy policies assert it to be. The report looks at the forests of Estonia – one of the EU's top wood pellet producers – as a case study. EU rules and national subsidy schemes that encourage the use of wood pellets to meet renewable energy targets are driving the destruction and degradation of forests in Estonia. The study found that even the Dutch sustainability criteria fail to protect critical habitats like high-conservation-value forests and peat lands and ensure that renewable energy production in the Netherlands is not complicit in this destruction. The destruction of these ecosystems for wood pellet production, and the intensification of logging, threaten biodiversity and undermine the ability of the forests to act as carbon sinks (WAL, 2021). Many Balkan countries (part of developing countries) use wood for heating purposes, for example in Bosnia and Hercegovina the results of a research showed that wood fuels were used by 71.59% of total number of households. The author suggest a sustainable and more efficient use of wood fuels for heat energy in order to contribute to increasing the share of renewable energy by using local energy sources (ČOMIĆ ET AL., 2021). In Serbia most households (40.9%) used solid fuels such as fuel wood, coal, briquettes, pellets, agricultural residues and combinations of solid and other fuels (GLAVONJIĆ, 2011). Concerning individual heating, an estimated 62% of households in North Macedonia are using wood, while in Kosovo on average, 85% of urban homes use wood as their main source of heating, while in villages, wood for heating is 100% (BOWEN ET AL., 2013). According to JAGGER AND KITTNER (2017) (a study from Uganda), due to high deforestation rate there is an increased use of crop residues. FAZEKAS AND TUERK (2016) conclude that the impacts of biofuels on deforestation are being shaped by countries' political and institutional framework and socioeconomic settings. Effects also depend greatly on the particular feedstock used. The POLIMP experts urge for new research focusing on the potential impact of second generation lignocellulosic biofuels on deforestation to better understand the relationship between biofuel development and deforestation, and associated social and environmental impacts (FAZEKAS AND TUERK 2016). As straw is an important source for heating, in many developing countries is usually burned on field, while in many papers it is overestimated due to methods used for calculation, which we will discuss in the following chapters.

3.1.1 The Importance of Wheat Straw Biomass Energy (Heating and Cooling)

According to GABRIELLE & GAGNAIRE (2008), cereal straw is considered a potentially significant source of energy supply with an estimated value of 47 x 10^{18} J worldwide, and their results showed that straw removal had little influence on environmental emissions in the field. Straw can help achieve forest management objectives by reducing wildfire risk and improving forest health, productivity, and habitat for some species (NAKAMURA, 1996). Agricultural residues are available in limited quantities; however, they have advantages in environmental sustainability because they involve the reuse of waste, minimising negative environmental externalities (LANFRANCHI, 2012). E.U. policy encourages the use of crop residues instead of dedicated crops to reduce the land-use by non-food crops (SUARDI ET AL., 2020). The most significant potential source of feedstock for SGB production in Europe is straw from wheat (SCARLAT ET AL., 2010). Straw from wheat production has multiple applications, including animal bedding, mushroom production substrate, and feedstock for biomass-burning power stations (COPERLAND & TURLEY, 2008). Production of wheat in the world is 690 Million tons/year. The main producers of wheat are Asia (41%), Europe & Russia (31%), and North America (13%). The EU28 by itself accounts for 20% of global wheat production (139 Million tons or 44.0 % of all cereal grains harvested). 90% of that amount is consumed within the E.U., 10% is exported outside the E.U. At the global level, 67% of total wheat is used for food purposes, 18% for feed, 0.9% for biofuels, and 10% for other uses. Only at the E.U. level, the use of wheat for biofuels reaches a significant level (3.5% of wheat consumption) (EUROPEAN COMMISSION., 2017). Over the last decade, there have been increasing incentives and interest in utilising straw as feedstock for renewable energy in response to renewable fuel standards and energy markets (MINER ET AL., 2014). SMIL (1999) stated that significant parts of the global production produced in agriculture are by-products, especially straw from crops. Straw currently makes up the largest potential of agricultural residues. Its potential depends on the sustainable extraction rate to maintain soil quality and the competitive uses of residues (for example, animal bedding); both factors vary per country. Overall, wheat straw contributes most to the total share of primary agricultural residues (dry matter) (42%), followed by barley and maise (both 19%). In many regions, straw is used to produce heat and/or electricity (EUROPEAN COMMISSION., 2017). However, straw and other agricultural residues used for energy purposes and innovative biobased products and materials remain low in Europe (with current use primarily to satisfy local heat demand) (IEAB, 2017). A more recent E.U. wide project (S2Biom) found a technical potential of the crop and agro-industrial residues for the EU28, Western Balkans, Turkey, and Ukraine by 2030 of 400,000 million tonnes of dry biomass per year, while its current use is 15,000 million tones (PANOUTSOU ET AL., 2016). Countries which show considerable increases in the use of straw for energy purposes towards 2020 and 2030 are Poland, France, the U.K., Romania, Hungary, and Denmark (GRADZIUK ET AL., 2020). Denmark typically uses around 1.0-1.5 Million tons per year (PANOUTSOU ET AL., 2016). Due to large production quantities, homogeneous properties, and the possibility of value creation in rural areas, straw is considered a feedstock suitable for various material and energy-related applications (DEA, 2017). In practice, the availability of cereal straw for a bio-energy plant depends on numerous factors, including

biomass produced within the field, harvesting height of straw, cereal varieties grown, and the relative proportions of straw to grain biomass (GLITHERO, RAMSDEN, ET AL., 2013).
The use of agricultural biomass is separated in two ways:

Biomass from agriculture Energy crops

1. Conventional food crops (starch, sugar, or oilseed crops)
2. Non-food energy crops (perennial grasses, short rotation coppice)

Agriculture residues

1. Primary or harvest residues (like straw, corn stover) produced in the field
2. Secondary residues from the processing of harvested products (like bagasse, rice husks). The total contribution of secondary agricultural residues remains small.
3. Manure

Extra-EU supply

1. Wood pellets from forest products and residues
2. Agripellets from agriculture residues
3. Liquid biofuels (EUROPEAN COMMISSION., 2017).

3.1.2 The Practice of Straw Burning

Agriculture and electricity are among the most important sources contributing 11% and 31% of the total human-generated greenhouse gas emissions (GLOBAL EMISSIONS, 2020). Waste products which are the main contributors to biomass burning are wheat residue, rice straw and hulls, barley residue, maise straws and leaves, and millet and sorghum straws (YEVICH & LOGAN, 2003). In particular, the burning of agricultural waste has been proven to be a non-negligible source of CO2 emissions leading to global warming (YAN ET AL., 2015). Burning of the stubble fields and organic residues in agriculture is one of the oldest practices in Europe and worldwide (NIKOLOV, 2011) especially in developing countries. Study carried by of SUN ET AL. (2016), the CO2 which was emitted by crop residue open burnings, occupied around half (45.09%) of the total residential coal consumption, which has also seriously hindered the environmental governance and sustainable development in the rural areas (CHENG ET AL., 2011). Many authors give evidence about biomass loss, air pollution from burning straw on-field as well as land degradation (ANDREAE, 1991; CHALCO VERA ET AL., 2017; NGUYEN & NGUYEN, 2019; SEILER & CRUTZEN, 1980; Y. WANG ET AL., 2010) and one of the main causes of forest fires (NIKOLOV, 2011) thus their suggestion is to avoid this practice. Burning of stubble fields and organic residues in agriculture is one of the oldest practices in Europe and worldwide (NIKOLOV, 2011). Though it is banned by law, in many developing countries, this practice still exists (KOSHY, 2019; LIQUN ET AL., 2016). According to SKØTT (2011), straw that has not been removed is usually burned in fields after harvest. The main reason for burning straw on-field is 'inadequacy of government initiatives (DHALL ET AL., 2020) or low rate of straw utilisation/the absence of straw disposal (MCNULTY & GRACE, 2009), low market rates of residue, lack of farmers proper education on implications of crop residue burning, intention to clear land rapidly and inexpensively, preparation of soil ready for re-planting (GROVER ET AL., 2015), combination of a lack of incentives as well as lack of suitable equipment for gathering crop residues (particularly specialist machinery for bailing), transporting and storing them; reduction in livestock, lack of good information for small farmers on alternative uses of residues and the belief that soil tillage practice is better after straw burning (REN ET AL., 2019; STAN ET AL., 2014), because in the short- term, they would avoid pests, weeds, and other diseases as well as with low cost instead of incorporation, better preparation of seedbed in a burned field (NIKOLOV, 2011; Y. WANG ET AL., 2010), and return nutrients to the soil (HAO & LIU, 1994). However, from this practice, there are more disadvantages than advantages. As it was mentioned above, there are also many reports on straw burning in the past like; CRUTZEN & ANDREAE (1990), who report that 25% of crop waste is burned in the fields of developing countries in the tropics, SEILER & CRUTZEN (1980) and ANDREAE (1991) proposed that 80% of available residues are burned in developing countries and 50% in developed countries, while HAO & LIU (1994) assumed that 23% of residues are used as fuel, and 17% are burned in the field. In Turkey, one of the largest wheat producers in the Middle East, farmers traditionally burn the wheat and barley residue in the fields after animals graze (WHITMAN ET AL., 1989). In Iran, crop residues and weeds provide about 70% of livestock feed and are almost completely removed from the land (FENSTER, 1989). Within the drylands of Pakistan, no part of a crop is returned to the soil; stubble is grazed by livestock (KHAN ET AL., 1989). In England and Wales, up to 41% of wheat straw was burned on arable land before the ban (SILGRAM & CHAMBERS, 2002), while in Egypt, this figure was 52% (HAMDY, 1998). During the 2002-2013 period in the Philippines, India, Egypt, Thailand and China, the percentages of straw burned in the field were approximately 95%, 62%, 53%, 48% and 62%, respectively (ABDELHADY ET AL., 2014; GADDE ET AL., 2009; LIQUN ET AL., 2016), while a recent study in China has revealed that around 26.67% of farmers burn straw (ZUO ET AL., 2020). In China, straw utilisation rate was 80% in 2015, and as a country, it can significantly reduce coal use, accompanied by a reduction of 75 million tonnes of CO_2 emissions, if the conversion of total straw yield into bioenergy would increase to 21% (from 11% in 2015) (REN ET AL., 2019). In contrast, straw burning is a rare practice in the United States (REN ET AL., 2019). Many regions or countries, e.g., the U.S., E.U., China, India, Australia and Southeast

Asia, have banned straw burning, although these bans were likely based on a singular view that is still under debate (PANDEY ET AL., 2017; TORE, 2019). Even so, immediate cessation of on-site burning worldwide is implausible because there is a lack of consensus in many rice-based countries, where the governments cannot involve farmers in alternative practices that are more effective (PANDEY ET AL., 2017). This outcome suggests that such bans need stronger evidence or incentives to cause farmers to change their method of handling straw (NGUYEN & NGUYEN, 2019). Whilst burning may be useful to control pests and disease in certain crops, incorporation of residues into the soil has an important role to play in increasing soil organic content and improving soil structure, resulting in higher productivity, for example, the ploughing-in of straw accounts for as little as 11 per cent of the total straw resource in Poland, but 30-40 per cent of total supply in England and the Czech Republic and as much as 60 to 70 per cent in France (KRETSCHMER ET AL., 2012A). A similar situation is apparent in Slovenia, where incorporation of straw into the soil is necessary to build better soil functionality on particularly poor soils (SCARLAT ET AL., 2010). Literature that offers us a general methodology to evaluate crop harvesting and procurement based on sustainability criteria (maintaining soil fertility, nutrients, and carbon content; and preventing other uses) is limited (BATIDZIRAI ET AL., 2016). Therefore, our two research questions are: 1) Why has the once-widespread practice of burning straw changed in countries where it is no longer part of everyday practice? Moreover, 2) What changes in the market or regulatory conditions are required to avoid this polluting production practice?

3.1.3 How does E.U. Agricultural Policy Support Green Transition?

European Commission, through various policies affects the reduction of straw burning and on the other side there are policies that increase the incentive to use agricultural waste by offering various renewable energy investments. Within E.U. agricultural policy, support for production and use of bioenergy in rural areas has been strengthened: renewable energy and climate change are priorities for which the E.U. has substantially increased financial resources available. However, it is not easy to conclude Europe as a whole on the amount of straw needed to remain on the field to prevent reductions in soil organic matter and soil functionality because this depends on local soil and climatic conditions (KRETSCHMER ET AL., 2012A). Biomass from forestry will remain the primary source, but biomass from agriculture will show the most significant increase by 2020 (ELBERSEN ET AL., 2013). Farmers decide where they want to sell their products: on food, feed or energy market. As the E.U. obligation to double the use of renewable energy by 2020 is strongly driving demand for biomass, the energy market will likely become more critical. Support for renewable energy can take many different forms, ranging from investments in physical capital to human capital (such as training). Here are some examples of relevant projects supported by the

E.U. funding (through rural development programs: 1) building biogas plants; 2) planting trees for short-rotation coppicing; 3) installing heating systems that run on straw, wood pellets or low-value timber; 4) establishing perennial energy grasses; 5) crushing oilseeds on the farm and using pure plant oil as fuel for farm machinery. In addition, the E.U. encourages Member States to use more wood from forests in a sustainable manner and make wood use more efficient. Without any doubt, the increasing global demand for a range of commodities – energy and food, feed, and raw materials - will put pressure on virgin land and certain social groups; this is why the E.U. requires biofuels to be sustainable. The ultimate objective is to ensure that whenever biomass is used for energy in the E.U. with support from our Member States, this does not damage the environment, jeopardise efforts to mitigate climate change or bring about negative social effects. If used wisely, bioenergy will help us to green our energy supply. That is why the E.U. strongly supports the production and use of sustainable bioenergy. The European Commission also supports sustainable and circular bio-based sector through the implementation of the Bio-economy Action Plan (EUROPEAN COMMISSION., 2018); they aim to turn waste from farming into new added values products, develop substitutes to fossil-based materials that are bio-based, replace fossil material with renewable alternatives such as bioenergy and provide additional income for farmers. According to VANHAMAKI ET AL. (2019), in a Circular Economy (C.E), the value of products and materials is maintained for as long as possible. What has previously been considered waste is now a resource that can be reused and reintroduced to the production cycle as bioenergy too. Therefore, waste management of technical and bio-based waste streams appears to be the main driver in transition towards a Circular Economy.

3.1.3.1 Policies Regarding Straw Burning on Field

When it comes to burning of straw and stubbles, this has been banned in most Member States under compulsory Good Agricultural and Environmental Condition (GAEC) standards as applied under the Common Agriculture Policy. The minimum standards for good agricultural and environmental condition (GAEC) of land were established by Regulation (E.U.) No 1306/2013 in 2013. One of the main issues is "soil and carbon stock" where GAEC 4, 5 and 6 states: "Minimum soil cover", "Minimum land management reflecting site-specific conditions to limit erosion", and "the maintenance of soil organic matter level through appropriate practices including the ban on burning arable stubble, except for plant health reason" following the statement "The requirement can be limited to a general ban on burning arable stubble, but a Member State may decide to prescribe further requirements" (E.U. 2020). A number of E.U. Member States have used their Rural Development Programme, part of the Common Agricultural Programme (CAP), to provide fiscal incentives for straw to be left on fields following harvest and its incorporation either following the harvest or before cultivation in spring (KRETSCHMER ET AL., 2012A). Therefore, there is now a presumption that beneficiaries of the CAP should not burn agricultural residues, although national standards may include several exemptions, including the control of pests and disease. Only four Member States: Cyprus, France, Ireland, and Slovenia, do not impose a ban on burning of arable stubbles under cross-compliance GAEC standards. For example, in Slovenia, farms operating integrated production systems (with or without livestock) may be required to incorporate straw under specific certification systems or as a condition of support provided through measures within Rural Development Programmes. According to the Guidelines for Integrated Crop Management (ICM, part of Slovenian Environmental Programme in Agriculture), where the soil's humus content is lower than 1.5 per cent, straw must be incorporated and cannot be taken off-site or disposed of through burning. Generally, in southern Europe, permission for agricultural burning is given by local or regional authorities; Member State may allow derogations based on local conditions, such as those that permit it when wind speeds are low to prevent forest fires, but these are conditions when the impact on air quality are the highest.

In contrast, some Member States which also ban straw and stubble burning under national legislation, for example, Denmark and England where bans exist at national level (since 1991 and 1993) (in the same time, these two countries, together with France, have the highest wheat yields (KRETSCHMER ET AL., 2012A) and such restrictions provide incentives for incorporation of straw into soil, and its use for other farming purposes or as a renewable fuel. For solid biomass, the E.U. has no sustainability criteria for removing straw. Intelligent Energy Europe (2010) regarding biomass from agricultural cultivation and harvesting activities like straw/stubbles (cereals, sunflower) barley and wheat, rye and oats, other cereals area only stated "Loss of soil fertility if too much straw is removed" (ELBERSEN ET AL., 2010; GLITHERO, RAMSDEN, ET AL., 2013). Regarding sustainability criteria in the study of ELBERSEN ET AL. (2013) for solid biomass feedstock, there are only recommendations formulated by the European Commission (E.C.) to be adopted voluntarily by the E.U. member states (M.S.). In other countries, there are bans, but there are no economic incentives to incorporate straw or use it for other purposes for example, in Russia, Romania, China, India, Spain (NGUYEN & NGUYEN, 2019). According to AIRUSE (2016) burning straw is possible where emissions can be more effectively controlled.

3.2 Circular Economy

According to ENEL (2008), circular economy is a strategic ally of sustainable development. Its broad vision is essential to redesigning how we address scarce resources, global warming, and waste management. There are many definitions of circular economy. After reviewing 114 definitions, KIRCHHERR ET AL., (2017) propose the current report "A circular economy describes an economic system that is based on business models which replace the 'end-of-life' concept with reducing, alternatively reusing, recycling and recovering materials in production/distribution and consumption processes, thus operating at a micro-level (products, companies, consumers), a meso-level (eco-industrial parks) and a macro-level (city, region, nation and beyond), to accomplish sustainable development, which implies creating environmental quality, economic prosperity and social equity, to benefit current and future generations. According to ENEL (2008) Circular Economy's broad vision is essential to redesigning how we address scarce resources, global warming and waste management. Circular economy is a business model with enormous potential, capable of generating competitiveness by combining innovation and sustainability. However, to implement this model, it is necessary to change the traditional approach to the market, customers, and natural resources. Technological innovation, environmental sustainability, energy efficiency, and renewable sources travel in symbiosis, giving circular economy the characteristics of a new virtuous system. Energy transition and circular economy are the themes of the moment and involve all the actors of the society. The goal is to protect the environment, reduce emission of harmful gases, pressures on natural resources, achieve sustainable growth and create jobs. In this context, renewable sources take place instead of non-renewable ones; this is a long and complex process but full of opportunities and advantages (ENEL 2008; EUROPEAN COMMISSION., 2020). One of the main objectives of a circular economy is to make sustainable products a norm, ensure less waste and make them work for people (EUROPEAN COMMISSION., 2020).

According to SCHULZE (2020), systematic waste management can significantly contribute in achieving the United Nations' Sustainable Development Goals. To a certain extent, this also applies to circular economy, which relies on both reductions in the amount of waste and consumption of resources and increased use of secondary raw materials. The increasing scarcity of resources makes circular economy an essential resource management element and contributes to climate protection (KRANERT & CLAUß, 2018). Vast quantities of waste are generated along the food chain during harvesting, transport, processing, storage, distribution, of retailing (BELC ET AL., 2019). Specifically, circular economy must promote loops when socially desirable and efficient (ANDERSEN, 2007).

3.2.1 Circular Economy and Social Equity

Between 2012 and 2018, the number of jobs linked to circular economy in the E.U. grew by 5% to reach around 4 million. Circularity can be expected to positively affect job creation, provided that workers acquire the skills required by the green transition. The potential of the social economy, which is a pioneer in job creation linked to circular economy, will be further leveraged by mutual benefits of supporting green transition and strengthening social inclusion, notably under the Action Plan to implement the European Pillar of Social Rights (EUROPEAN COMMISSION., 2020). A key aspect of sustainable development is strengthening social foundations and reducing poverty, promoting equality within and between generations. Fair access to resources is vital for equal opportunities for current and future generations (BETTENCOURT & KAUR, 2011). However, circular economy has so far paid very little attention to both intra and inter-generational equity. According to KIRCHHERR ET AL. (2017), the main aim of circular economy consists of three dimensional; economic prosperity, followed by environmental quality, its impact on social equity and future generations which is barely mentioned. The author KIRCHHERR ET AL., (2017) highlights that very few studies deal with the three dimensions, as most of them only considered economic prosperity and environmental quality, leaving social equity unmentioned, which makes circular economy unsustainable.

Several authors (KIRCHHERR ET AL., 2017; MOREAU ET AL., 2017; MURRAY ET AL., 2017; SAUVÉ ET AL., 2016) claim that social equity is usually absent on the C.E. concept, including unequal distribution of wealth, income and labour conditions (SCHOR, 2017). For instance, GENG ET AL., (2009) states that C.E. would aim to bring significant social benefits. According to CRAMER., (2017), all forms of product reuse potentially form a huge economic motor in circular economy and, hence, more jobs. On the other side, SCHOR., (2017) highlights that the C.E. may increase inequalities due to disadvantages that low-income, less-educated people have regarding access. Yet, the impacts of the C.E.'s social equity impacts remain largely unknown (Kirchherr et al., 2017; Murray et al., 2017). As circular economy brings extra income to agriculture, some authors declare that nonfarm income can increase inequality between farmers (IQBAL ET AL., 2018; KMOCH ET AL., 2018; MAT ET AL., 2012; WOLDEHANNA & OSKAM, 2000) and other authors (AL-AMIN & HOSSAIN, 2019; KIMHI, 2009; MÖLLERS & BUCHENRIEDER, 2011) who state that it decreases inequality; thus, we will analyze the impact of extra income on farmers. We are going to explore income determinants of rural household and their effects on wellbeing and equality. In the absence of extra income from circular economy regarding residues of agriculture, we will treat nonfarm income/extra-income outside agriculture to measure inequality.

3.2.2 Circular Economy in Agriculture and Nonfarm Income

Europe is generating 1.3 billion tons of waste annually, of which 700 million tonnes are agricultural waste (PAWELCZYK, 2005). According to JUN & XIANG (2011), implementation of Circular Economy is an inevitable option for sustainable agricultural development. Implementing an agricultural Circular Economy is the key base of the overall national economic and social system to develop Circular Economy and establish a recycling society. The traditional linear model of economy is based on "production > consumption > disposal" while circular economy models are based on "production > consumption > recycling > reuse" (DONIA ET AL., 2017; LACY ET AL., 2016; PAOLOTTI ET AL., 2016). Applying circular economy principle to agriculture is a critical contemporary issue on the international political and economic agenda. Considering that, by 2050, the world's population will reach nearly 10 billion, raw materials will be increasingly scarce (EHRLICH & HARTE, 2015). To satisfy the demand for food by 2050, agricultural production must increase by 70% across the globe and by nearly 100% in developing countries (F.A.O. 2009). This increase would greatly impact gas emissions, in total, 5 billion tons CO_2 eq/yr comes from crop and livestock production and 4 billion tons CO_2 eq/yr due to net forest conversion to other lands (a proxy for deforestation) and 0.2 billion tons CO_2 eq/yr by biomass fires. Despite the ban on residue burnings, many countries still use this practice (ABDELHADY ET AL., 2014; GADDE ET AL., 2009; LIQUN ET AL., 2016; ZUO ET AL., 2020). The largest source of GHG emissions within agriculture is enteric fermentation (40%). When methane is produced by livestock during digestion and released via belches, followed by manure left on pasture (16%), synthetic fertilizers (13%), rice cultivation (generate methane 10%), manure management (7%), burning of savanna (5%), and less than 5 % crop residues (consist of direct and indirect N_2O emissions from nitrogen in crop residues and forage/pasture renewal left on agricultural fields by farmers.). There are also emissions from energy use in agriculture which exceeded 785 million tons of CO_2 eq. in 2010 (from traditional fuel sources, including electricity and fossil fuels burned to power agricultural machinery, irrigation pumps and fishing vessels) (TUBIELLO ET AL., 2014). An agricultural system conceptualized this way is not sustainable and is destined to collapse, especially under growing demographic pressure. A response to these problems could come from circular agriculture, through the possibility of recovering the resources taken out of the land but still in circulation (waste products). The remaining resources are waste from agri-food industries, manure, organic substances, by-products as straw from cereals. Recovering these substances creates sustainable agriculture, preserves soil fertility through reconstructed biodiversity (DONIA ET AL., 2018), generate additional income for farmers (EUROPEAN COMMISSION., 2018) and help find appropriate use for refuse and organic wastes

(DONIA ET AL., 2018). The agriculture sector produces significant amounts of organic residue, and the choice of the management strategy of these flows affects the sector's environmental sustainability. The scientific literature is rich with innovative processes for producing bio-based products (BBP) from agriculture residues, aimed at implementing circular economy principles (AMATO ET AL., 2021). The author DONIA ET AL. (2018) analyzed business investments in renewable resources from a circular economy perspective by studying a biogas plant that uses waste products by the vineyard itself. According to the author circular economy is an economic system designed to regenerate on its own; indeed, in circular economy, every waste product becomes a resource. Some resources can be taken from one production scheme and used in another without being discarded. The circular economy concept is based on recovering onsite resources that are still circulating (overproduction, waste) instead of importing them from abroad. Recovering these substances creates sustainable agriculture (DONIA ET AL., 2018). Production of feedstock for renewable energy and renewable energy generation itself can positively influence the sustainable socio-economic development of a region, and public support is needed (MARKS-BIELSKA ET AL., 2019). Many economic activities in lower-income countries revolve around sorting and reusing waste. However, higher-value, employment-generating opportunities for reuse and remanufacturing waste are yet to be captured (PRESTON & LEHNE, 2017). Reduced pressure on natural resources is also correlated with nonfarm incomes (BARRETT ET AL., 2002). The WORLD BANK, (2017) suggested an integrated approach of combining farming with tourism which has the potential to improve the livelihoods of rural populations by reducing unemployment, rural migration and overall poverty (JĘCZMYK ET AL., 2015; CIANI ET AL., 2016; HÜLLER ET AL., 2017; NUNKOO AND GURSOY, 2012; IQBAL ET AL., 2018). Another nonfarm generating activity is also using biomass residues for energy, leading to increased crop yields; besides reducing poverty, it is also environmentally friendly (KUROWSKA ET AL., 2014; ROZBICKA & SZENT-IVÁNYI, 2020; YMERI ET AL., 2020). According to DAIOGLOU ET AL. (2016), the use of straw is attractive as they are not related to direct or indirect land-use change issues; they are estimated to have a low cost as they are by-products of existing operations. The emissions of CO_2 to the atmosphere produced to obtain biomass, as they proceed from a carbon withdrawn from the atmosphere in the same biological cycle, do not affect the equilibrium of atmospheric carbon. Thus they do not increase the greenhouse effect. And in cases where they substitute for fossil fuels, use of agrifibres contributes to reduced net emissions of CO_2 to the air (MARTÍNEZ, 2006). Related to farmers' perceptions of challenges facing bioenergy development, ZYADIN ET AL. (2019) found that the biggest challenge was migration of young people to cities or less interested in farming. The second one was lack of seasonal workers during harvest time. Growers worldwide are often challenged annually to eliminate harvest residues from their farms, and they strive to do so without creating environmental problems or unnecessary costs. To burn stubble is a questionable practice in many areas, as it often damages soil and the environment, and it may harm health (B ET AL., 2016). Improvement in agricultural practices (e.g. better crop varieties, soil management, weed control, education of farmers, advanced machinery) and the possibility to process residues into energy-dense feedstocks (pellets and briquettes) have made this source an attractive (ZYADIN ET AL., 2019). Funding for environmentally friendly causes aligns with European non-governmental development organizations' positions, stressing that poverty reduction needs to be ecologically sustainable (ROZBICKA & SZENT-IVÁNYI, 2020). In many developing nations, off-farm income has become an essential element of living standard schemes among rural people (BABATUNDE & FAKAYODE, 2010; MAT ET AL., 2012) and is widely associated with poverty reduction (HAGGBLADE ET AL., 2010; MAT ET AL., 2012). For example, in Latin America, the share of nonfarm income in the total income is around 40%, while in Ecuador, it is 36% (KÖBRICH & DIRVEN, 2007). In India, on the other hand, in the early 90s percentage of income from nonfarm activities was 34% (P. LANJOUW & SHARIFF, 2004), in Kedah- Malaysia, it was 32.35% (MAT ET AL., 2012), while in Croatia, it was 31.7% (MÖLLERS & BUCHENRIEDER, 2011). Nonfarm income is more profitable than all forms of farm labour, which shows its potential for reducing rural poverty (VASCO & TAMAYO, 2017). Study conducted by ZYADIN ET AL. (2017) is reported that farmers who do not consider farming as their only source of income are more willing to cultivate feedstock for energy generation; this can be related to financial characteristics such as off-farm incomes, on the other hand, time constraints from working off-farm and land tenure arrangements may prevent a farmer from supplying wheat straw as a cellulosic biomass source, as well (ALTMAN ET AL., 2015). Nonetheless, these transformations on the farm level require substantial investments from the E.U. funds.

3.2.3 Income Determinants Among Rural Households

Understanding household livelihood strategies is pivotal in minimizing rural poverty in the least developed countries (PAUDEL KHATIWADA ET AL., 2017). Almost two-thirds of the world's poor people reside in rural areas of low-income countries, mainly depending on subsistence farming and other natural resources for their livelihood (WORLD BANK INTERNATIONAL MONETARY FUND, 2014). In addition, rural populations experience the highs and lows of a global economy, for if the price of their crop drops, then their sustainability is affected (MCCATTY, 2004). Although poverty is a multi-dimensional issue, it is directly associated with a household income, asset holding, and other economic activities that determine its livelihood strategy and outcomes (WORLD BANK, 2014). Widespread poverty can be found in volatile Balkan states (BEZEMER, 2006), Kosovo is one of them (MAZREKAJ, 2016). Despite considerable economic growth (3.9% growth of G.D.P.), Kosovo has faced a slow job creation process, and its employment rate remains one of the lowest in Europe. Mainly the long-term unemployment rate is high: 25.9% in 2019 compared to 6.2% in the EU-27 in the same year (TRADING ECONOMICS(A), 2000; TRADING ECONOMICS(B), 2000), and the rates of extreme poverty are considered to be even higher in rural settlements (A.S.K., 2019). Agriculture is likely to remain crucial for alleviating poverty, particularly in the poorest countries (MACOURS & SWINNEN, 2006). In Kosovo, around 61% of people live in rural areas, and agriculture remains a significant source of income and employment (with participation of 9% in the Gross Domestic Product) (M.A.F.R.D. 2017). On the other side, migration is a strategy that can compensate for low employment rates (CORBANESE & ROSAS, 2007). In Kosovo, most of the migration happened during the war and was directed towards different countries. Rural-urban migration, on the other hand, is a result of the destruction of agriculture and properties.

Nonetheless, migration persists due to overall high unemployment rate and both, migrations outside of Kosovo and from rural to urban areas within Kosovo partly explain Kosovo's low self-sufficiency rate for agriculture products as imports are (87.6%) higher than exports (HAXHIKADRIJA 2009; GOLLOPENI 2015; WORLD BANK 2017; M.A.F.R.D. 2018). Kosovo's high poverty and unemployment data, as well as migration trends, highlight the importance of investing in nonfarm activities. According to BYTYÇI & GJERGJIZI (2015), rural families are often forced to work outside of their farms to increase participation required on farmers' budgets. Different authors discussed avoiding poverty in rural areas (KABIR ET AL., 2019; KHINE MYINT CHO ET AL., 2019; LYU ET AL., 2019). As agricultural employment is generally associated with an elevated poverty risk, rural nonfarm income may offer a new opportunity in this situation (KABIR ET AL., 2019). Distinguishing that poverty is positively and significantly associated with income inequality (ARAUJO, 2004; RAVALLION & DATT, 2002), researchers differ on how farmers can best generate off-farm income. The first approach is that off-farm work can reduce short- and long-run income inequality and allow poor farmers to increase their capital stock (AL-AMIN & HOSSAIN, 2019; KIMHI, 2009; MÖLLERS & BUCHENRIEDER, 2011). On the other hand, the second approach adopted by other researchers (IQBAL ET AL., 2018; KMOCH ET AL., 2018; MAT ET AL., 2012; WOLDEHANNA & OSKAM, 2000) found that off-farm income itself can aggravate income inequality among farm households in rural areas as in many cases wealthy farmers tend to dominate the most lucrative and risky nonfarm activity. Nonetheless, for Kosovo and other European candidate countries, empirical evidence regarding non-farming income is still patchy. To promote broader concepts of rural development (e.g. the call of revised Common Agriculture Policy for reorientation of farming from product-centred towards more entrepreneurial modes of agriculture by diversifying both agronomic and non-agricultural activities) (STANOVČIĆ ET AL., 2018), a better understanding of the levels of nonfarm income and its implications for poverty and inequality is essential.

3.2.4 The Importance of Rural Nonfarm Income and its Effect on Poverty Alleviation

To deal with different challenges concerning agriculture in Europe (like decreasing farm revenues, price fluctuation, low productivity growth rates, migration), it is appropriate to diversify agronomic and non-agricultural activities in the rural areas by adopting new entrepreneurial competencies (STANOVČIĆ ET AL., 2018). In doing this, competitive ability of the agricultural sector and its sustainability would be increased (STANOVČIĆ ET AL., 2018). Different authors suggest that off-farm income can reduce rural to urban migration rates caused by rural unemployment (and underemployment) (KHINE MYINT CHO ET AL., 2019). LYU ET AL. (2019) support the policy interventions that focus on generating employment opportunities in rural areas to reduce migration flow to urban areas. Farm household income can be categorized as an earned off-farm income (wages and salaries), unearned off-farm income (migration, social security, pensions, and investments), and farm net cash income (MAT ET AL., 2012; MÖLLERS & BUCHENRIEDER, 2011). According to different studies, nonfarm activities can increase agricultural investments (MARENYA ET AL., 2003). However, as poverty is related to reduced levels of education and low overall work competencies, poor farmers tend to be reluctant to migrate to urban areas (HAAN & ROGALY, 2002). Thus, the government needs to support small and medium-scale rural enterprises and agriculture (OKHANKHUELE & OPAFUNSO, 2013). In the case of transition economies, DAVIS & PEARCE (2000) suggest a deepening of analysis on the labour force on agricultural households by studying additional parameters or variables. The individual's decision to continue or cease farm work can depend on adaptation to the favourable situation on (off-farm) labor markets ('demand-pull factors). On the other hand, a continuation of (low-paid) farm work can also be an individual's survival strategy in the case of rigidity on off-farm labour markets (distress push factors). Even though the importance of off-farm incomes is increasing day by day in rural areas, it has been difficult to see the effect of non-agricultural rural employment on poverty reduction. KIMHI (2009) results show that nonfarm income is an equalizing source of income in these countries, Georgia, Korea, Ethiopia and Croatia (MÖLLERS & BUCHENRIEDER 2011).

On the other hand, findings of different authors (IQBAL ET AL., 2018; KMOCH ET AL., 2018; MAT ET AL., 2012; WOLDEHANNA & OSKAM, 2000) shows that off-farm income is one of the sources of income inequality among farm households in rural areas because of wealthy farmers dominate the most lucrative and risky nonfarm activity such as masonry, carpentry, and trading. In addition to this, if there are entry barriers to and rationing in the labour market, diversifying income into off-farm activities will be more difficult for the poor than for the wealthy farm households (DE JANVRY & SADOULET, 2001; WOLDEHANNA & OSKAM, 2000). Accordingly, the first hypothesis assumes a linear decreasing curve of the share of nonfarm incomes from the poorer to the better-off families (MACDONALD, 2006). In contrast, the second hypothesis assumes an increasing curve. According to J. O. LANJOUW & LANJOUW (1997), it is mainly the poorest and the wealthiest households that are engaged in rural nonfarm employment, meaning that they tend to seek u-shaped relationships between nonfarm incomes and total incomes.

3.2.5 Farmers' Attitudes Towards the Use of Biomass as Renewable Energy

Promoting recycling economy needs to improve community awareness of environmental protection and resource conservation (JUN & XIANG, 2011). Specifically, circular economy must promote loops when socially desirable and efficient (ANDERSEN, 2007). According to GAUS ET AL. (2013), farmers' decision-making determines the amount of straw available on the market. Many authors calculated the available biomass based on different sustainability coefficients and competitive use; however, when different authors took into account the willingness of farmers to sell straw, availability of straw changed (GAUS ET AL., 2013; GIANNOCCARO, 2017; GLITHERO, RAMSDEN, ET AL., 2013). According to GIANNOCCARO (2017) assessment of biomass availability has generally been focused on technical and agronomic feasibility, while in the economics of biomass it is possible to apply another method to calculate the availability of biomass. This method takes into consideration the willingness of farmers to supply (GAUS ET AL., 2013; GIANNOCCARO, 2017; GLITHERO, RAMSDEN, ET AL., 2013). A comparison between these approaches and convention alone could lead to new interdisciplinary collaborations, and this type of data could be used as a basis for further studies. ALTMAN ET AL. (2015) argue that "willingness to supply research is critical in the early stages of commercialization of new technologies and industry development". Therefore, research aiming at understanding farmers' perceptions is vital to successfully design and present economic incentives and policy initiatives (PANNELL ET AL., 2006). There are different scientific papers where willingness to supply straw is applied; GLITHERO ET AL. (2013*a*) estimated straw yields based on straw use area, number of straw bales, and willingness to sell straw. GIANNOCCARO (2017) took data from farmers on a range of topics, including farming practices, farm profile, current straw uses, sociodemographic data, and farmers' willingness to deal with the energy market and sell their straw. According to GAUS ET AL. (2013), farmers' decision-making determines the amount of straw available on the market. Straw producers in his study sample were willing to sell on average 45% of their annual straw production, and with a higher price, more straw would be sold. In the study of GLITHERO ET AL. (2013*a*), in England, farmers were willing to sell 43% of their total wheat straw; however, this percentage changed according to different parts of England, and the variation was from 33.21% to 67.35%. While in the study of ZYADIN ET AL. (2017), these percentages are 16% and 37%. According to PANNELL ET AL. (2006), producer demographic variables, such as age, education level, off-farm income, land tenure and experience with selling biomass in the past, are likely to impact a producer's willingness to supply. These demographics help capture differences in farmers' preferences due to different situational circumstances (PANNELL ET AL., 2006). Different studies (ALTMAN ET AL., 2015; ALTMAN & SANDERS, 2012) found that commercial developers and policymakers could expect modest supply responses for each dollar increase in price. Based on ALTMAN ET AL. (2015)'s findings, maximum percentage of biomass supply for energy in Missouri was 38.1% and in Illinois was 46.5%, while for corn was from 33.5 to 40.9% under ideal conditions (price and market). Their study revealed that farmers were less likely to supply straw when they had more renting land, land planted with wheat, corn and hay (ALTMAN ET AL., 2015), environmental concerns (ANAND ET AL., 2008) when they wanted to store biomass on-farm, had a baler, an off-farm work (ALTMAN ET AL., 2015) and higher size of land (ZYADIN ET AL., 2019). Most of these factors depend on time constraints and prices; furthermore, older farmers are part of this group as they are uncertain about entering a new market (ALTMAN ET AL., 2015; ZYADIN ET AL., 2019). On the other hand, farmers were more likely to supply when they own a vehicle that can transport biomass to market, have a prior history of selling biomass; similar results from factors mentioned above are found in different studies (ALTMAN ET AL., 2015; ANAND ET AL., 2008; CALDAS ET AL., 2014; PANNELL ET AL., 2006; WILLIAMSON, 1985; ZYADIN ET AL., 2019). The study of ZYADIN ET AL. (2015) revealed that Indian farmers from all states are willing to sell their surplus biomass directly, preferably without middleman involvement, to an energy producer. The majority of the farmers perceived the establishment of a biomass-based power plant in their region with positive economic outcomes; thus, around 97% of farmers want to sell their straw surplus for energy market by (36–73 Euros/ton), however, from total straw, the average share of straw for energy purposes in percentage % is not specified. The farmers may also benefit from the by-products, such as ashes- as a mineral fertilizer for their agriculture fields.

Contrary, ZYADIN ET AL. (2019) reported a situation in Poland where biomass market was not at its best due to low demand, low prices accompanied by increased biomass imports. As a result, only 31% of farmers reported surplus biomass for sale, and only one-third agreed that selling biomass would increase their income. However, it was not clear at which minimum price farmers were willing to sell the biomass. JIANG ET AL. (2018) conducted a study related to psychological factors on farmers' intentions to reuse agricultural biomass waste for carbon emission reduction; they found that attitude and perceived behavioural control influence farmers' intentions to reuse biomass waste. Farmers who had low income, low education, and more farming experience had fundamental needs to be met; therefore, social pressure towards reusing biomass waste on the farmers' decisions is relatively weak. If farmers can perceive and assess the ecological or economic benefits of reusing agricultural biomass waste based on their knowledge, resources, and technologies, in that case, they become more confident to participate in a carbon emission abatement program. In the study of SHEHRAWAT ET AL. (2015) in India, awareness among the farmers about utilization of agricultural waste was very high as farmers were well educated and had regular mass media contact. However, they found a big gap between awareness and utilization; for example, awareness about utilization of wheat straw was 72.33%, while the utilization of wheat waste was only 12.87%. This difference existed due to a lack of interest among framers. Thus there is a need to motivate farmers, which can be made possible by organizing training, lectures, showing films to farmers or demonstrating waste management techniques in the field (SHEHRAWAT ET AL., 2015). Wheat straw can be used for making many products, but all the farmers store it and use it for animal feed, and 57.50% of farmers sell wheat straw as feed for animals (SHEHRAWAT ET AL., 2015). The main aims of this study is to estimate the amount of straw that farmers are willing to sell for bioenergy purposes, to determine the socio-economic factors that impact farmers' willingness to sell straw by separating them into two groups: farmers who are willing to sell less straw and farmers with higher amount of selling (less than 50% and more than 50%), and to analyze the potential barriers to and incentives toward selling straw for bioenergy. Thus, the study applied binary logistic regression to determine which variables were significant and shaped the willingness to sell straw.

3.2.6 Market Players of Biomass

According to TOWNSEND ET AL. (2017), straw has a vital role in the future of renewable energy production, and burning straw in combined heat and power facilities appears to be the most appropriate use of straw as much higher efficiencies can be achieved this way, compare with producing biofuels. Biomass is a typical local fuel, which should be utilised by local individual energy consumers, and which should be the primary fuel for distributed cogeneration plants producing electric power and thermal energy (MARKS-BIELSKA ET AL., 2019). Biomass processing, such as palletisation or briquetting, is recommended for efficient transportation of biomass at longer distances to reduce transportation costs (ZYADIN ET AL., 2015). Straw, agricultural residues and stumps can be utilised in heating plants if mixed with forest residues, stem wood, etc. This utilisation would give farmers and forest owners additional incomes and heating plants a broader range of materials and suppliers (PERLACK, 2005). The disadvantage is that the low bulk density of straw limits use of straw to regional or country levels. Therefore, most studies restrict subtraction of straw from neighbouring regions in case of deficits (EUROPEAN COMMISSION., 2017). Based on data taken from (IEAB, 2017) in Denmark, share of straw for energy purposes is the highest in CHP, District heating, individual use, and bioethanol, consecutively. The market players in Kosovo (figure 4) can be Districts Heating and pellet producers. The most significant barriers in the market are seen as lack of suppliers in Pristina and Kosovo – mainly because of lack of demand (WBIF, 2017). The GHG emissions of extra-EU imported solid biomass are in general higher than emissions of domestic sources of biomass. However, large bulk ocean carriers are relatively efficient compared to road or rail transport. In some cases, GHG emissions of overseas imported biomass pathways are lower than solid biomass traded between E.U. member states (EUROPEAN COMMISSION., 2017).

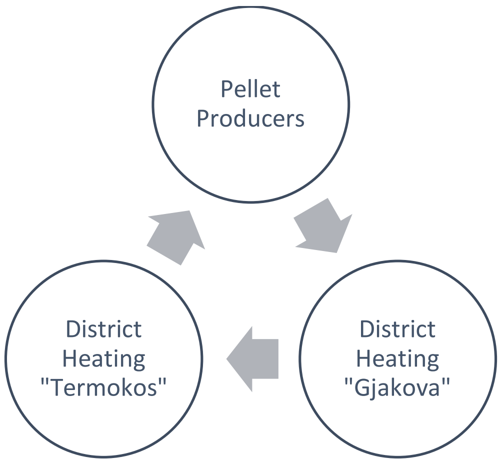


Figure 4. Potential Market Players of Biomass From Straw in Kosovo
Source: Author's own construction

3.2.6.1 District Headings

Ely Combined Heat and Power plant (270 GWh plant) uses 200,000 tonnes collected per annum, on average, within a 48 km radius per annum and describes itself as the largest straw burning plant in the world (GLITHERO, RAMSDEN, ET AL., 2013). The Sleaford power plant, currently under construction, is expected to use 240,000 tonnes, almost all of which is expected to be collected again from within a 48 km radius (TOWNSEND ET AL., 2017)

District heating' or 'district cooling' means the distribution of thermal energy in the form of steam, hot water, or chilled liquids, from a central source of production through a network to multiple

buildings or sites, for the use of space or process heating or cooling (EUR-LEX, 2009). Kosovo has only two district heating systems; based on LIMANI & BAJRAKTARI'S (2013) study, district heating currently covers only 5% of the total heating demand in Kosovo.
One is *"NQ. Termokos,"* located in Prishtina (capital city); its heating energy comes from cogeneration deriving from the lignite-fired power plant Kosova B which is 10.5 km from district heating. The district heating system has an installed capacity of 140 MWth and an operating capacity of 137.48 MWth, covering around 13,700 (12,427 residential consumers and 1,273 commercial/public). District heating "Termokos" also has its thermal energy generation capacities by using boilers fired by fuel oil which are currently not being used due to the utilisation of cogeneration and may be used only during peak periods or if there is a shortage of supply from the power plant - Kosova B. In total, the district heating Termokos has the following generating capacities for thermal energy, 274 MWth (installed capacity) and 252.28 MWth (operating capacity); thus, total capacity can be achieved only by using coal. It is estimated that in Prishtina (capital city), 20% Heat Demand in schools could be covered using available wood residues with an investment of 0.8 M EUR, while in general, 40% of Heat Demand in Kosovo schools could be covered using available wood residues with an investment of 0.8 M EUR (WBIF, 2017)

The other district heating is *"NQ. Gjakova"* it is located in the city of Gjakova, it uses coal fuel oil for its two boiler stations, their installed capacity is 38.6 MWth, and available capacity is 27.82 MWth, it covers (1055 households or 6.5% of total households and 795 commercial/public) (ERO, 2020; WBIF, 2017). However, the European Commission invested in this district heating, the cogeneration biomass-fired district heating plant is first ever in Kosovo and covers 40% of population in the city (RAMADANI, 2021). Each has a nominal capacity of 5.5 MWth and one cogeneration unit with 1.10 MW electricity and 4MW thermal (ERO, 2020). The additional Heating Use Potential of biomass in Gjakova to supply district heating is estimated to be 58,372 MWh (15,536 t), where the share of straw is the highest (35%), corn stover (31%), logging residues (18%), vineyard prunings (16%). The municipality of Gjakova and a private partner jointly establish a biomass supply entity. The municipality provides funding for the site area, buildings, and storage/collection facility machinery. Private partner undertakes daily operation and management of the facility (WBIF, 2017).

3.2.6.2 Pellet Producers

Some E.U. Member States have started to develop extensive sustainability schemes with specific sustainability criteria for solid biomass from forests and agriculture for renewable energy purposes (BANJA ET AL., 2017). After energy conversion, the product must be delivered to final consumption, whether in the form of electricity, heat, or more tangible products, such as pellets/briquettes and bio-fuels (LAUTALA ET AL., 2015). Straw has been described as a 'more attractive' feedstock for pelleting as it has lower moisture content than wood, and if the seasonal conditions are optimum, it may not require artificial drying before it can enter the pelleting process, reducing energy balance from producing them (SULTANA & KUMAR, 2011). One of the most critical barriers to increased biomass utilisation in energy supply is cost of the respective supply chain and the technology to convert biomass into valuable forms of energy. According to RENTIZELAS ET AL. (2009), 20–50% of biomass delivered cost is due to transportation and handling activities. The most-traded biomass fuel is pellets because pellets are the most compact form of solid biofuels, so transport costs per energy unit are the lowest, which is essential, especially with longer distances (SÉNÉCHAL ET AL., 2009). Pellet manufacturers and suppliers try to establish local markets and co-operate with local wood and timber industries (SÉNÉCHAL ET AL., 2009). Burning wood pellets to produce electricity is on the rise in Europe, where pellets are classified as a form of renewable energy.

Nevertheless, in the U.S., where pellet facilities are rapidly being built, concerns are growing about logging and the carbon released by the combustion of wood biomass (DROUIN, 2015). It is expected that global demand for biomass will increase enormously in the coming years; this will cause prices to rise and increase the risk of overexploitation of forest resources with loss of biodiversity and, as a result, increased greenhouse gas emission. Power plant companies have been focusing their import of wood pellets in recent years. However, many reports state that the imported wood pellets in Europe are not produced sustainably (FAZEKAS & TUERK, 2016; IEAB, 2017; NRDC, 2020; TIMILSINA & MEVEL, 2013; WAL, 2021). Pellet is a relatively new product in the Kosovo market and is rising very fast. Total market size for pellets is difficult to determine due to undeclared imports (it is worth mentioning that domestic production is limited due to wood sources capacity) and local production. However, the rough estimate of total sales in the Kosovo market was 24,000- 57,000 tons in 2014-2016 (ENGLISCH, 2018). According to ENGLISCH (2018), there are three leading pellet manufacturers in Kosovo, and there is only one manufacturer that produces bricked from pruning vineyards; the number of small manufacturers is unknown. The value chain is heavily dependent on wood materials from local forests, which is rapidly becoming a scarce resource due to high demand and illegal logging. On the opportunity side, there is a robust and rapidly growing demand for pellets as a cost-effective alternative to other energy sources (MODÉER, 2015). Demand for pellets in the Kosovo market is strong and growing fast, driven by several socio-economic factors, such as improvement in living standards and increased cost of electricity. Pellet is in competition with heating energy from power plants, Oil, Electricity (MODÉER, 2015). According to MODÉER (2015), pellets are cheaper than oil, gas, and electricity. Thus, Kosovo must know the availability of straw, as there is a lack of information available.

3.3 Measurements of Straw Produced

The assessment of crop residue availability contains inherent inaccuracies due to multiple factors (SCARLAT ET AL., 2010). Equipment use, harvest facilities, traditional attitudes, and climate influence harvesting, threshing, and storage techniques for grain and straw (JOSHI ET AL., 1995). Comparing cultivars based on straw yield is difficult as straw yield is rarely quantified (LARSEN ET AL., 2012). In general, there is limited straw yield data available for example, straw yields are not currently given in the Recommended list for U.K. cultivars, and there are no published records of straw yields for individual cultivars to aid farmers in selecting wheat straw yields (TOWNSEND ET AL., 2017). The same situation stands for Europe, where it is stated that "cereals which are grown for the production of grain are not considered as a dual-purpose crop as (long as) no data are requested for the by-product" (straw) (EUROSTAT, 2020a). Thus, very few resources are available to determine how much straw can be sustainably removed; this may be due to soil erosion historically being considered less of a problem in Europe than in the USA, where guidelines are available. The cultivar lists produced by the University of Kentucky appear to be unique among recommended lists (R.L.s) in offering straw yield data for wheat cultivars (TOWNSEND ET AL., 2017). There are two main reasons for this: firstly, straw is seen as a by-product to the more critical grain, with less incentive for it to be quantified as its economic value is much lower; secondly, straw yields are more difficult to quantify than grain yields, particularly on trial plots, due to straw losses and movement between combining and baling, as well as the need for specialist equipment to take account of topography to have an even level of stubble for each plot (TOWNSEND ET AL., 2017). There is uncertainty regarding the amount of straw chopped and incorporated, and, taken together with uncertainty regarding the amount of straw that can be sustainably harvested, it is unclear how much straw is available for bioenergy production. Other reasons for not quantifying the amount of straw are uncertainty about the amount of straw currently used and straw yield (TOWNSEND ET AL., 2017); this means that the amount of straw that can be baled and the frequency of baling depend on location. This variability means that it is difficult to recommend how much residue should be left on the field. There appears to be little information available for farmers in Europe on how much straw they can remove. Straw availability may also be overestimated as calculations often assume that all farmers who can sustainably supply straw will supply that straw, whereas, in reality, many farmers are unwilling to do so because of, for example, concerns about negative soil impacts and potential delays in planting subsequent crops (GLITHERO, RAMSDEN, ET AL., 2013). For the current project, the question of sustainability of straw removal is not extensively addressed. In general, it is assumed that straw is only harvested where it is sustainable to do so, and some material is left on the field (i.e., the stubble and chaff), which is sufficient to prevent negative impacts on the soil.

In general, different studies discussed the amount of wheat residues that are available to use for energy purposes, most of them found this amount based on suggestions from literature review like; the report grain to straw, the amount of straw which needs to stay on land, and the amount of straw for other uses like feed and bedding (CAI ET AL., 2008; KUMAR ET AL., 2015; LANFRANCHI, 2012; YANLI ET AL., 2010).

Different studies used the percentage of straw that can be used for energy without further discussion of the amount for other use (CAI ET AL., 2008; KARAJ ET AL., 2010; SAHITI ET AL., 2015). On the other side, several authors declare that straw can change depending on crop variety, climate change, land, type of harvest, fertilisers, etc (BATIDZIRAI ET AL., 2016; DONALDSON ET AL., 2001; GALLAGHER & BISCOE, 1978; LARSEN ET AL., 2012; PELTONEN-SAINIO ET AL., 2008; SKØTT, 2011; YEVICH & LOGAN, 2003). Therefore, estimating the amount of residue that must be left on cropland is a challenge and entails a high degree of uncertainty since it depends mainly on local conditions (SCARLAT ET AL., 2010). Thus, the amount of straw or the ratio of grain to residue is not always the same. On the other hand, different studies are trying to find out the best method of measuring the aboveground biomass of wheat by using precision technology which will help monitor and increase the yield (HOLMAN ET AL., 2016). In this way, studies tried to find out the correlation between height and yield while the amount of residue was not the focus of these studies as the focus was to use efficient technologies in monitoring wheat crops and estimate yields for developing adaptation strategies and mitigating adverse effects (HOLMAN ET AL., 2016). Other authors suggest that farmers' willingness also plays a vital role in straw availability (GIANNOCCARO, 2017; GLITHERO, RAMSDEN, ET AL., 2013; ZYADIN ET AL., 2015). DAIOGLOU ET AL. (2016) included different definitions of residue in their study, and three types of potentials explained in detail what they contain. In figure 5, we can see the three types of potentials and discuss each of them.

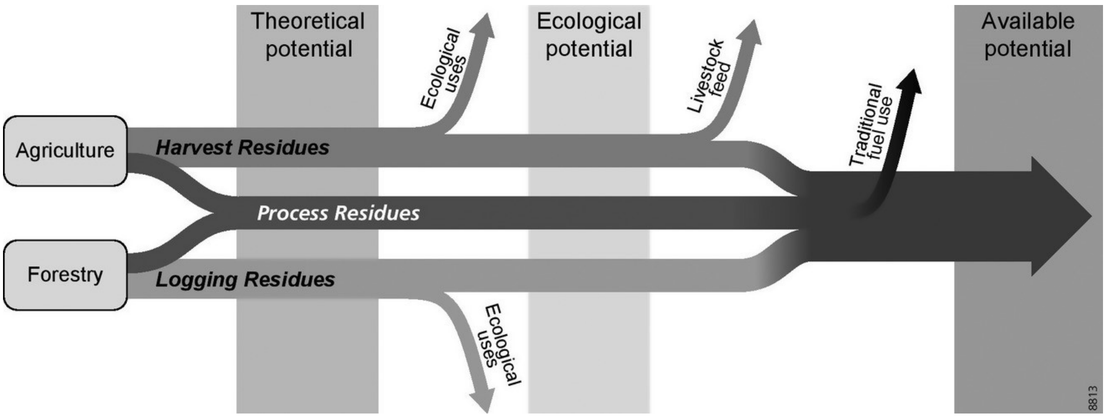


Figure 5. Type of Potential Biomass Residues
Source: DAIOGLOU ET AL. (2016)

3.3.1 Theoretical Potential

The theoretical potential comprises the absolute maximum volume of residues produced on given projections in agricultural productivity. It acts as an upper limit of the availability and does not consider environmental or economic constraints, recoverability, and possible current uses (DAIOGLOU ET AL., 2016). Various measurements of potential straw for energy purposes were analysed; most of them related to the theoretical potential of crop residues based on straw to grain ratio or harvest index, the area or production of each crop cultivated, and the average residue yields. CHINNICI ET AL. (2015) claimed that; different authors have proposed product to residue ratios method. This method has been widely applied to estimate agricultural residues availability for energy purposes. By this method, the primary production was determined; by using specific parameters related to the quantity of waste per unit of product and the percentage of residue used for other purposes, quantity of potentially available plant waste was determined (CAI ET AL., 2008; KUMAR ET AL., 2015; LANFRANCHI, 2012; YANLI ET AL., 2010). These data were usually found from regional or national statistical offices as well as from the literature or referenced local trials (ANGELIS-DIMAKIS ET AL., 2011; KARAJ ET AL., 2010; LEWANDOWSKI ET AL., 2006; SAID ET AL., 2013; ZHANG ET AL., 2019; EZEALIGU AT AL., 2021); for example, in the analysis of SCARLAT ET AL. (2010) AND MONFORTI ET AL. (2013), areas and residual product ratio data were taken from the literature, and government data, SCARLAT ET AL. (2010) also used crop residue-to-yield ratios, depending on crop yields; crop residue removal rate according to environmental constraints and requirements for soil conservation; competitive use of crop residues. According to SCARLAT ET AL. (2010), the relationship between residue-to-seed production is very specific to the type of crop and plant variety. It is complicated to make a straightforward estimation of this ratio since it is influenced by climate and soil conditions and the farming practices (tillage, density of planting, fertilisation, etc.). HAKALA ET AL. (2009) highlights that there is a reasonable relationship between yield and residue. Residue-to-grain ratios are often used to predict straw yield from grain yields for trials where straw yield has not been measured, usually assuming a direct or linear relationship between grain and straw yields(R. E. ENGEL ET AL., 2003). On the other hand, some authors suggest using the Harvest index (the ratio of grain to aboveground biomass) instead of ratio of straw to yield (JOSHI ET AL., 1995). Using HI, a non-grain biomass can be calculated, which can be used as a proxy for straw yield.

3.3.1.1 Disadvantages of Harvest Index and Straw to Grain Ratio for Measuring Straw

HI is not a perfect indication of the amount of straw available as it includes chaff, the majority of which is likely to be lost during baling, as well as stubble. The other disadvantage of H.I. and ratio straw to grain is that the relationship between straw and grain yields is variable (HAY, 1995; LARSEN ET AL., 2012). According to DONALDSON ET AL. (2001), straw yields are often calculated from average straw-to-grain ratios that might not reflect actual yield relationship during the year the estimate is made. However, under conditions without severe stress or abnormal chemical treatments, a relationship can be reasonably fixed as demonstrated by consistency in H.I. as reviewed by HAY (1995). In DAI ET AL.'S (2016) study, significant harvest index variability was detected within and between wheat classes; Harvest Index ranged from 0.33 to 0.61 while an average overall wheat classes and regions were HI= 0.45. According to the crop's cultivation site and the variety HAKALA ET AL. (2009) claim that the amount of harvestable residue varies even within a crop species. Following this, in the study of GLITHERO ET AL. (2013B), there was no clear relationship between harvested grain to straw yields for wheat because the correlation was weak and not significant, similar results are found in the study of LEE & GROVE (2005) where it is stated that higher grain yields do not always translate into higher straw yields. According to SCARLAT ET AL. (2010), the variation in grain to straw yields observed for three crops (wheat, barley, and oilseed rape) is greater than it would be expected from previous estimates of residue to grain ratios. In the study of ROTH & STREIT (2018), dry biomass differed essentially between species and samples. LARSEN ET AL. (2012) found considerable temporal variation, with 46% variation in yearly averages, which was hypothesised to result from differences in weather between years. These environmental factors interact with genotypic factors (R. E. ENGEL ET AL., 2003), further complicating identification of high straw-yielding cultivars. According to Donaldson et al. (2001), straw yield or straw to grain ratio can change based on the sowing date and sowing density; moreover, it depends on the type of cultivar (DONALDSON ET AL., 2001; LARSEN ET AL.,

2012; PELTONEN-SAINIO ET AL., 2008; SKØTT, 2011) with taller cultivars showing greater variability (R. E. ENGEL ET AL., 2003), for which again many authors usually do not take into consideration the most used types of cultivars from farmers when calculating the amount of straw for energy purposes. However, the effects of environment and management appear to exceed those of genetics (JOSHI ET AL., 1995). Straw yield can also change depending on nitrogen and water availability (R. E. ENGEL ET AL., 2003), fungal infections, and, therefore, fungicide treatment (JØRGENSEN & OLESEN, 2002). Climatic conditions also have a considerable influence on straw yields; large-scale assessment of wheat straw yields. Under environmental and management conditions, H.I. can fluctuate significantly, particularly under adverse field conditions and crop stress, crop rotation, farming practices (e.g., soil cultivation, tillage), soil physical properties (BATIDZIRAI ET AL., 2016; GALLAGHER & BISCOE, 1978; LINDEN ET AL., 2000), fertilisers (YEVICH & LOGAN, 2003). When unfavourable conditions occur, it is likely that straw yields are more heavily impacted than grain yields as plant increases resource allocation to grain (LINDEN ET AL., 2000). The amount of straw can also depend on straw harvesting point or type of combine harvester used (GLITHERO, WILSON, ET AL., 2013; SKØTT, 2011; STUMBORG ET AL., 2011), among other factors ZYADIN ET AL. (2019) mention that education of farmers and advanced machinery makes the use of straw for energy more attractive. There is considerable variation in the literature for straw-to-grain ratios which are described in table 1. The reason for the extensive range of values is that several factors mentioned above influence these ratios.

Table 1. Variations of Ratio Straw to Grain on different wheat Cultivars

Authors	Ratio (straw/yields) kg.
(KONVALINA ET AL., 2014)	1: 1.91, 1: 1.52, 1: 1.60, 1: 1.81, 1: 1.24
(RUIZ ET AL., 2012)	1: 1.3
(GRADZIUK ET AL., 2020; J. J. LI ET AL., 2001; SAHITI ET AL., 2015)	1:1
(SINHA ET AL., 1982)	1.30 - 3.20
(R. ENGEL ET AL., 2005)	1: 1.33 1: 1.67
(H. LI ET AL., 2017)	1: 1.34 1: 0.93 1: 1.38 1: 1.23 1: 1.31

	1: 1.38
(D. JIANG ET AL., 2012)	1: 1.1
(YEVICH & LOGAN, 2003)	1: 0.9–1.6
(BARNARD & KRISTOFERSON, 1985)	1: 0.7–1.8
(W. WANG ET AL., 2020)	1:1.2
(SUARDI ET AL., 2020) baled straw	1: 0.43
(SUARDI ET AL., 2020) total straw	1: 0.94

Source: Author's own construction based on previous studies

LARSEN ET AL. (2012) aimed to identify cultivars with high straw yields which can be used as feedstock for biofuel; he found different straw yields which ranged from 2.7 t ha^{-1} to 4.2 t ha^{-1} in one field experiment and 3.4 t ha^{-1} to 4.6 t ha^{-1} in another (straw yield here refers to the amount that is baled and removed from the field). This measurement of straw baled is because some straw will be left on the field as stubble while other straw, particularly leaf and chaff, will be lost during combined harvesting and baling; this could account for 60% of total straw (BOYDEN, 2001). In the 2014 variety performance test of U.S. wheat cultivars, straw yields ranged from 1.23 t ha^{-1} to 3.88 t ha^{-1} with an average of 2.67 t ha^{-1}. Straw yields were unrelated to grain yields, suggesting that cultivars can be selected for high straw yields from those with high grain yields. However, relative rankings of 37 cultivars common to 2012, 2013, and 2014 field trials demonstrate inconsistencies over time for some cultivars; for example, the cultivar *Pioneer variety 25R32* had the lowest straw yield in 2014, the fourth-highest in 2013, and the seventh lowest in 2012. This is in contrast to *Syngenta SY 483* that had the highest straw yields in 2014 and 2013 and the third-highest in 2012 (TOWNSEND ET AL., 2017). LARSEN ET AL. (2012) has compared several winter wheat cultivars over two years in multiple locations (two in the first year and three in the second); his results indicate greater variability in straw yields than grain yields and found a significant difference between cultivars in their assessment of straw yield of modern wheat cultivars. According to ENGEL ET AL. (2005), grain to straw relationships differed greatly with cultivar in spring wheat, while winter wheat has more straw than spring wheat. Because of these variations with cultivar and location-specific factors, TOWNSEND ET AL. (2017) suggest that ratios need to be calculated for individual cultivars and locations to predict straw yield from grain yield accurately. According to JOSHI ET AL. (1995), because of the large effects of environment and management on straw quality and quantity, it is necessary to undertake such studies over at least five years and at a number of locations. This needs considerable resource inputs even if applied only for varieties ready for release. The summary of authors who mentioned different factors which impact the amount of biomass produced, which are given below (table 2):

Table 2. Factors influencing the amount of straw available for energy

Factors	Authors
1. Sowing date and sowing density	(DONALDSON ET AL., 2001)
2. Cultivar type	(DONALDSON ET AL., 2001; LARSEN ET AL., 2012; SKØTT, 2011)
3. Amount of nitrogen and water availability	(R. E. ENGEL ET AL., 2003)
4. Fungal infections and Fungicide treatment	(JØRGENSEN & OLESEN, 2002)
5. Climatic conditions, during and after harvest	(R. E. ENGEL ET AL., 2003)
6. Management conditions	(LINDEN ET AL., 2000; YEVICH & LOGAN, 2003)
7. Soil physical properties	(BATIDZIRAI ET AL., 2016)
9. Type of combine harvester used	(STUMBORG ET AL., 2011)
10. Competitive uses	(GLITHERO, WILSON, ET AL., 2013)
11. Willingness of farmers to sell	(GLITHERO, WILSON, ET AL., 2013)

Source: Author's own construction based on previous studies

3.3.1.2 The Potential of Precision Technologies for Biomass Measurement

Promoting the use of digital technologies for tracking and mapping resources is one of the main actions of the European Union towards a circular economy (E.U. 2021). Dealing with theoretical potential of wheat biomass guides us to focus on precision technology, which could be a solution in future studies related to straw supply for renewable energy, as the report grain to residue is fragile within varieties and location and can change every year. Aboveground biomass (AGB) is a widely used agronomic parameter for characterising crop growth status and predicting grain yield (N. LU ET AL., 2019). Accurate and rapid estimation of AGB is crucial for assessing crop nutrition status and improving crop management strategies. Conventional estimation of AGB is based on destructive measurements (GNYP ET AL., 2014), which are time-consuming and labour-intensive and hard to apply over large areas (BOSCHETTI ET AL., 2007). Remote sensing as a non-destructive technique has been proved to have great potential in AGB estimation for different crops, including wheat (JIN ET AL., 2016). There are different studies in the field of precision technology that measure aboveground biomass. Unmanned Aerial Vehicles (UAVs), also referred to as Unmanned Aerial Systems (UAS), is a growing technology rapidly gaining popularity in public and scientific communities. UAVs offer a customisable aerial platform from which various sensors can be mounted and flown to collect aerial imagery with very high spatial and temporal resolutions. The review of relevant literature has shown UAV-based SFM is applicable to the modelling of plant heights; however accuracy of models achieved in these studies highlights that improvements are needed. It is clear that a proof of concept has been achieved; however, developing this concept into a working procedure applicable to real-world agricultural research is now the next step (HOLMAN ET AL., 2016). Many studies have estimated the biomass with this type of technology; for example, PANDAY ET AL. (2020) estimated wheat's AGB and crop yield using the plant height derived from consumer-grade RGB drone images. Their focus was to estimate crop yields; thus, they measured the plant height, spike, and grain weight (spike =0.6-0.93 kg/m2) (grain =0.44-0.67 kg/m2). The predicted spike and grain weights were 6.54 tons/ha and 4.53 tons/ha, respectively. The difference between direct field measurement and from drone was reported to be 5%-11.9%. The authors found a moderate (R^2 of 0.66) relationship between the AGB and the plant height. The relationship between crop yield and plant height was stronger (with R^2 of 0.73 and 0.70), respectively, for the spike and grain weights. Similar R^2 values (0.74) have been reported for biomass from BATISTOTI ET AL. (2019), who predicted the amount of biomass by estimating the canopy height using UAV. They conclude that this statistical quality assurance contributes to crop yield estimation, hence developing efficient food security strategies using earth observation and geo-information. The study also concludes that plant height can be economically estimated using images acquired with consumer-grade drones. Further, this study infers that wheat AGB and yield can be reasonably and competitively estimated by measuring plant height from crop surface models (CSMs) prepared from drone images. Biomass measuring is described as an evaluation, the objective of which is to quantify dry matter present above ground level per unit area (Hodgson, 1979). In the study of SCHIRRMANN ET AL. (2016), wheat canopy and plant height was measured; the minimum fresh biomass was reported to be 0.90 and maximum was 5.67 kg/m2 while on dry biomass was 0.47 kg/m2 to 1.76, HOLMAN ET AL. (2016) also measured crop height and growth rate. The study highlights the potential of precision technology to become a new standard for measuring phenotyping of in-field crop heights. LU ET AL. (2019) made the aboveground biomass estimation in wheat based on vegetation indices, canopy height metrics, and their combination using precision technology. Estimation of AGB (ton/ha) in wheat was also made manually on the field (leaves, stems, and panicles), which was around 3.86-15.88 ton/ha; however, their weight was expressed all together in tons and not separately. Similar studies are made by different authors (GITELSON ET AL., 2002). ROTH AND STREIT (2018) calculated AGB based on canopy cover (CC), plant height (P.H.), and vegetation indices (VIs). He found a significant positive relationship between plant height and biomass. The authors claim that expanding the knowledge of the relationships among P.H., VIs, and biomass will presumably lead to speedy progress in precision agriculture. In general, there is a strong correlation between straw yield and plant height (R. E. ENGEL ET AL., 2003; LARSEN ET AL., 2012; LONG & MCCALLUM, 2013). ENGEL ET AL. (2005) found straw yield based on straw height, grain yield, and soil N availability. Their findings demonstrate that, even though there is a positive relationship between height and yield, it is highly variable, and their finding is valid only for the cultivars measured in those studies and cannot be used more widely. However, some authors do not agree with the strong relationship between straw yield and height; for example, DONALDSON ET AL. (2001) found that straw yields of a semi-dwarf cultivar did not differ significantly from standard height or tall cultivars, and it may be possible to increase straw yield without increasing height. Many farmers use shorter cultivars and choose management practices to escape straw lodging from the weather; however, BRAGG ET AL. (1984) found that although reduced plant height, did not significantly influence straw or grain yields. Recently a study found a way to measure the amount of straw by precision technology, based on straw yield monitoring system, which works in three elementary steps: measurement of straw moisture content, total number of bales, and weight of individual bales using sensors. As both of these sensors work, the information is sent to the driver cab and displayed on a screen, as well; the information is geo-referenced so it can be mapped and closely investigated at a later time or date (SHRINIVASA ET AL., 2017). LONG & MCCALLUM (2013) used on-combine light detection and ranging (lidar) in mapping straw yield, they found out that crop height measured by Lidar were strongly correlated (0.79) with crop height, which was measured manually from fields and was a good predictor of straw productivity ($r^2 = 0.85$) however they state that further work with Lidar is needed to resolve the issue of flying chaff. Crop height was better correlated with straw yield than grain yield or grain protein concentration. The newest findings are from HUAWEI MOU ET AL. (2021), who estimated the amount of winter wheat straw using GF-1 satellite images and found an error of only 1.27% on the measurement amount.

3.3.2 Ecological and Technical Potential

The degradation of the natural environment and the energy crisis are two vital issues for sustainable development worldwide (NI ET AL., 2006). Ecological potential is measured by theoretical potential minus residue requirements to avoid severe ecological degradation. In the study of DAIOGLOU ET AL. (2016), we can find three main types of biomass potential, a) theoretical, b) ecological, and c) available potential. While in the study of DEES ET AL. (2017), we can find that technical potential and ecological potential (constrains) are in the same dimension. Different studies include ecological potential within technical potential; for example, SCHLEGEL ET AL. (2006) and KARAJ ET AL. (2010) have discussed technical energy potential, which describes that proportion in theoretical energy potential which is used taking into account the given technical, structural, ecological and legal restrictions (available technologies of utilisation, efficiencies of the energy conversions, availability of locations, also because of competing uses, as well as structural, ecological and other restrictions). KARAJ ET AL. (2010) highlighted that technical yield potential is part of biomass assessment and describes it as the share of theoretical yield potential, which is useful as biomass under the given techniques of manipulation. Unlike with grain, where almost all is collected at harvest, a significant proportion of straw is left on the field after baling as not all biomass production is possible to collect from the field, a part of it are the underground biomass which is left in the soil, and the upper part which includes the stubble and smaller pieces of material such as leaf and chaff with available techniques is not possible (and desired) to be collected (SOKHANSANJ ET AL., 2008). According to RASSE ET AL. (2005), it is quite established that SOC accumulation mostly depends on the root carbon rather than aboveground carbon. For example, in HAKALA ET AL.'S (2016) study, if all straw was removed from the field (theoretical cutting height 0 cm and all straw harvested, 1-1.5 tons of root biomass would remain annually in the soil. The best description between these two relations: technical (according to harvest cut point) and ecological potential are found in the study of HAKALA ET AL. (2016) (figure 6), who found that cutting height has a significant impact on the amount of straw incorporated on land, which leads to increase or decrease of soil organic carbon content. The author compared different heights of wheat stubbles above the ground in cm and the amount of residues left on land and soil organic carbon conserved.

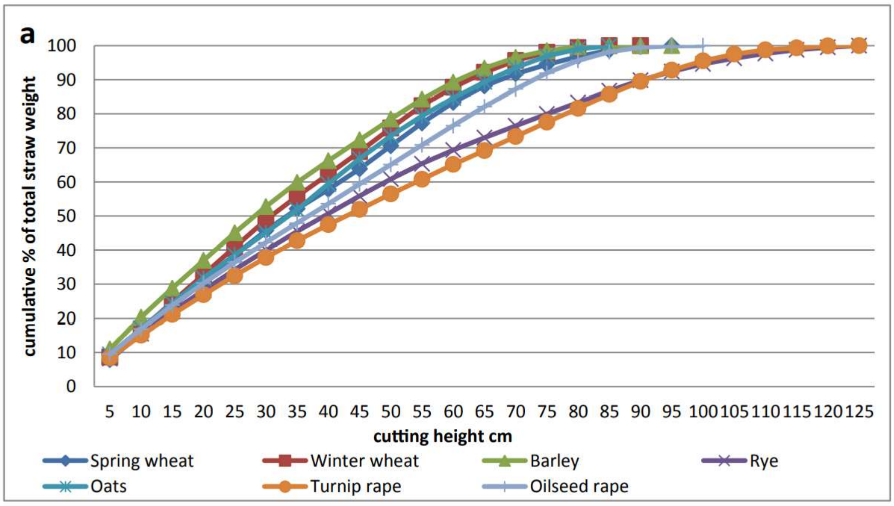


Figure 6. Straw weight and cutting height
Source: HAKALA ET AL. (2016)

According to HAKALA ET AL. (2016), higher stubble can provide more Soil Organic Carbon to the land. However, different crops were shown to behave very differently in their ability to maintain SOC. For example, winter wheat, which had the highest residue amounts under 20 and 40 cm cutting heights, conserved the SOC the best. The author suggests using a strategy of cutting the stubble 20cm above the ground every second year (instead of 40 cm or more every year) in this way it would decrease field traffic, thereby reducing soil compaction and work hours for farmers, while still significantly decreasing the GHG emissions and increasing biomass incorporation in the soil. FRISCHKNECHT ET AL. (2005) found that emissions from coal combustion are 130, from heavy fuel oil 95 and natural gas 70-77 g CO2 eq./MJ, while emissions from straw always remain below or equal to 3 g CO2 eq./MJ**.** This means that emission savings from using renewable straw as an energy source would be at least 67 g CO2 eq./MJ. However, increasing straw yield will influence collection costs. The proportion of straw collected varies with the equipment used. Lowering the height of the combine harvester header can increase the proportion of straw collected (BOYDEN, 2001), but this increases combine harvesting time with a decreased speed and increased fuel use (KEHAYOV ET AL., 2004). It is suggested that under standard conditions, only about 50% of the non-grain biomass can be baled (steam 5.7t/ha, leaves and dead shoots 2.1 t/ha, chaff 2.1ton/ha, and 9.4t/ha grain), even when the height of the combine cut is low (AHDB, 2017). Chaff make a considerable proportion to the total residues, COLLINS ET AL. (1990) reported values of 30% for chaff and 70% for straw, while MCCLELLAN ET AL. (1986) reported values of 33% chaff and 67% straw, respectively the samples in these studies were separated by hand, if these samples are measured mechanically with a plot combine instead of hand, then more straw would have ended up with chaff. The weight of straw in the chaff samples ranged from 25 to 29% of the total weight of chaff collected behind the combine where (straw yield refers to the yield of straw that is baled). BOYDEN (2001), in a similarly designed study using a harvest system of swath, harvest, and bale approach, reported values of 35–46% as the proportion of straw baled relative to the total mass of aboveground residues other than grain. They also showed that the amount of straw removed was not linearly related to stubble height. With 20-cm stubble heights, only 60% of the total straw was available for baling, and only 47% with stubble heights of 30 cm. In LAFOND ET AL. (2009) study, the stubble height averaged 10 cm, where only 26 to 40% of total aboveground crop residues other than grain are removed with baling. The proportion of aboveground residues other than grain was 55% for chaff and 45% for straw.

The other study of Lafond et al. (2009) showed that 50 years of straw removal did not influence spring wheat grain yield and grain protein concentration, and there was no measurable impact on the amount of SOC and SON. In his study, straw was removed two years out of three, with no addition of C in the third year because of fallow, and there was no difference in SON and SOC after 50 years (LAFOND ET AL., 2009). OPOKU & VYN (2011) estimated straw removal with baling at between 50 and 57% from studies conducted over two growing seasons. In the study of SUARDI ET AL. (2020), from the total amount of harvested residues, chaff represented 28% (1853kg/ha), uncut residues 20% (1617kg/ha), from the total residues around 46.5% (3710kg/ha) could be baled with a mean harvest index (i.e., the ratio between grain and total biomass) of 0.49. SUARDI ET AL. (2020) are trying to find a way to collect the chaff by admixing with straw in order to increase the residues collected without compromising grain harvesting and straw baling efficiencies while it can also reduce the energy needs for the bale logistics. However, further studies are needed to optimise chaff and straw recoveries (SUARDI ET AL., 2020). From Tables 3 and 4, we can see that the possible amount of total residues (%) to collect from the field with equipment used reported from different authors are in line with the authors who reported sustainable removal rate of residues from land.

Table 3. The possible amount of total residues (%) to collect from the field with equipment used

Authors	Collectable amount of straw
(BOYDEN, 2001)	35–60%
(AHDB, 2017)	50%
(LAFOND ET AL., 2009)	26-40%
(OPOKU & VYN, 2011)	50-57%
(SUARDI ET AL., 2020)	46.5%
(HAKALA ET AL., 2016)	65% every second year

Source: Author's own construction based on previous studies

Table 4. The sustainable removal rate of straw residues from land

	Sustainable removal rate	Competitive uses (% of available residues to competitive uses)
(VALIN ET AL., 2015)	33%–50%	Not included
(JINMING & OVEREND, 1998)	60%	23% (cattle)
(CAI ET AL., 2008)	60%	Not specified
(DEES ET AL., 2017)	50%	10%(animal feed)
(DAIOGLOU ET AL., 2016)	50-60%	32-50% (global average)
(ELBERSEN ET AL., 2014)	40%	other crops 50-70% (animal bedding and feed, mushroom production)
(FISCHER ET AL., 2010)	50%	Not included
(MONFORTI ET AL., 2013)	40%	16% (animal bedding)
(PUDELKO ET AL., 2013)	Max. 70%	not explicitly stated (animal bedding and feed)
(SPÖTTLE ET AL., 2013)	33-50%	70% (animal bedding and feed, mushroom production, industrial uses)
(DE WIT & FAAIJ, 2010)	50%	Not included
(SCARLAT ET AL., 2010)	15-60%	Not included

Source: Author's own construction based on previous studies and EUROPEAN COMMISSION (2017)

SCARLAT ET AL. (2010) found that the literature estimates for sustainable removal ranged from 15% to 60%, while yearly variation of crop residue ranges between +23% and 28% compared to the average data, as reference. According to DEES ET AL. (2017), approximately 50% of straw can be removed without reducing carbon content of the soil, although the level of removal varies greatly from region to region. PALMIERI ET AL. (2017) found out that incorporation of straw proved to be the best environmental practice but, in their current situation, concluded that selling straw on the local market for energy production was a better solution. According to GABRIELLE & GAGNAIRE (2008), straw removal had little influence on environmental emissions in the field of biomass. The E.U. has no general policy on removing straw for heating purposes (GLITHERO, RAMSDEN, ET AL., 2013). In the Globiom report, a study commissioned by the E.U. executive focusing on "indirect land-use change" (ILUC) distinguishes between sustainable and unsustainable plant residues. If the harvest of wheat straw is limited to a sustainable removal rate of 33%–50%, no yield-reducing effects occur, and consequently, the effect of ILUC is zero (VALIN ET AL., 2015).

3.3.2.1 Competitive Use of Straw

In the early eighties, research at the Institute of Soil Science and Plant Cultivation (IUNG) in Puławy showed that ca. 58% of harvested straw was used for bedding, 36% for fodder and 6% for other uses (covering mounds, isolating mats in horticultural farms, insulating buildings) (GRADZIUK ET AL., 2020). An increasing surplus of straw is caused by a decrease in livestock and thereby decreasing demand for (mainly) bedding (GRADZIUK ET AL., 2020). However, during 1999-2019, straw consumption (bedding and feed) decreased by approx. 60%. Demand for bedding declined continuously throughout the entire period. Consumption of straw for fodder after years of decline, since 2002, has remained at a relatively same level. These trends result from a decrease in the total livestock population and stabilization of ruminant populations (mainly cattle) since 2002 (GRADZIUK, 2015). Straw is also used in the horticulture sector, mainly for mushroom production, and in minimal quantities in the industrial sector (SPÖTTLE ET AL., 2013). The amount of crop residues used for competitive uses varies widely across countries. In particular, Ireland and the Netherlands use a higher share of the collectable crop residues for animal bedding (MONFORTI ET AL., 2013). Mushroom production mainly takes place in the Netherlands, France, Spain and Poland, currently utilizing approximately 5% to 31% of available straw in these countries (SCARLAT ET AL., 2010; SPÖTTLE ET AL., 2013). For example, the Netherlands has a low straw potential for bioenergy purposes because of low production and high competitive use from livestock and horticulture sectors (MONFORTI ET AL., 2013; SPÖTTLE ET AL., 2013). The volume of straw use per head of cattle in different regions is estimated to be on average between 0.1 and 2 tons per year (EDWARDS ET AL., 2005). Its use for this purpose, however, is highly variable and depends mainly on different types of livestock production (for example, whether cattle are out wintered, whether grazing takes place in lowland or upland areas etc.) and differs from year to year depending on stock numbers (KRETSCHMER ET AL., 2012B). A study that was conducted on South and Central Poland by ZYADIN ET AL. (2017) found that the majority of participants in two regions currently utilised biomass for animal feeding 29% and 42%, animal bedding 35% and 14%, or incorporation into the soil 27% and 18% and selling 1% and 10%. There was no report on burning the residues. Changes in how livestock are managed is another determinant of straw use within the livestock sector. For example, Denmark's increasing proportion of manure management is based on slurry, which does not use straw (or only in limited amounts) (KRETSCHMER ET AL., 2012B).

3.3.3 Available Potential of Straw for Energy

This section has highlighted that cereal straw is already widely used for a range of purposes in the E.U., and it is generally accepted that the existing agricultural resources, soil characteristics, site conditions and different agricultural farming practices should be taken into account when considering the removal of straw for bioenergy production (SCARLAT ET AL., 2010). Diversion of straw for other purposes, including production of biofuels, should also take account of the impact on such uses and any resulting environmental implications that may ensue. The overestimation of straw availability for biofuel production has important implications for policymakers. Better estimates of straw availability are required to inform decisions about the direction of renewable energy policy. Work is also needed to determine how straw use for bioenergy will compete with other users of straw (TOWNSEND ET AL., 2017).

Table 5. Available Biomass for Energy Purposes Based on Statistical Measurements from total straw

Authors	Available straw for energy
(WEISER ET AL., 2014)	27%
(WILLIAMS., 1995)	25%
(YAMAMOTO ET AL., 1999)	25%
(ALAKANGAS., 2011)	25%
(KARAJ ET AL., 2010)	25%
(FREAR ET AL., 2005)	25%
(YANLI ET AL., 2010)	62%
(CAI ET AL., 2008)	60%

Source: Author's own construction based on previous studies

The table above (table 5), represents different authors that used different percentage to calculate biomass for energy purposes. The available potential is usually found by statistics or different literature reviews similar to theoretical potential below are different authors that applied this method: According to WEISER ET AL. (2014), approximately 27% of straw can be classified as sustainable straw, and energy use of this straw can result in a 73.3%–92.3% reduction in greenhouse gas emissions compared to fossil numbers. JINMING & OVEREND (1998) suggested a collectable amount of around 60%, while Dees et al. (2017) suggests a removal rate of around 50%. Other studies assume that, of the total amount of agricultural residues available, approximately 25% can be recovered for bioenergy production and the remaining straw stubble is returned to the soil (ALAKANGAS, 2011; WILLIAMS, 1995; YAMAMOTO ET AL., 1999). In a study by MARKS-BIELSKA ET AL. (2019), potential straw was calculated based on statistics for; plant structure, amount of livestock and straw that must be ploughed into the soil. In a study by ZHANG ET AL. (2019), the amount of residue available for use was calculated based on specific parameters of each crop, which were recommended from the literature. CHINNICI ET AL. (2015) used coefficient availability, while CAI ET AL. (2008) calculated the quantities that can be collected (60%) after taking into consideration the quantities that must be left to maintain soil quality there parameters was taken based on literature review as well as the ratio of grass to grain. In the study of KARAJ ET AL. (2010) and FREAR ET AL. (2005), a sustainable collection factor of 25% and a moisture content of 28% was used to determine the final dry biomass of wheat straw for energy. For all straw crops (wheat, barley, ray, oat), 25% of the collection factor was used (KARAJ ET AL., 2010). In the study of GRADZIUK ET AL. (2020), ratio of seeds to straw was assumed to be 1:1, while straw demand for fodder and bedding was estimated based on livestock population and annual norms for individual species and utility groups. The occurrence of a negative balance of organic matter means a need to plough a certain amount of straw to maintain a sustainable balance of humus. In the study of YANLI ET AL. (2010), apart from 24% of which is used as animal feed and 3% as industrial raw materials, the rest of which is probably 73% of the total collectable amount can be used energy feedstock.

3.4 An Overview of Energy Sources in Kosovo

3.4.1 Renewable energy and achieved targets

Sustainable Energy involves renewable energy utilization and carbon dioxide saving measures (PEREA-MORENO ET AL., 2017). Energy recovery from organic fractions of different waste streams has a dual advantage of solving prevailing waste management problems while providing sustainable energy solutions to various sectors of the Economy (GEBREZGABHER ET AL., 2016). Just like all other European countries, Kosovo is in the process of fulfilling its obligations for covering a considerable part of its requirement for energy from alternative energy. In this context, a national plan was designed for action in alternative energy production (N.R.E.A.P. 2011-2020). The obligatory general target of partaking in energy from renewable energy in G.F.C.E. in 2020 is 25%, defined in the Decision of the Council of Ministers of the Community of Energy

D/2012/04/MC-EnC for implementation of Directory 2009/28/E.C. However, Kosovo made a voluntary R.E.S. target of 29.47 %, which is planned to achieve in 2020 (M.E.D. 2013). Gross final consumption of energy (G.F.C.E.) means the energy commodities delivered for energy purposes to industry, transport, households, services including public services, agriculture, forestry and fisheries, including the consumption of electricity and heat by the energy branch for electricity and heat production and including losses of electricity and heat in distribution and transmission (EUR-LEX, 2009). Data related to Kosovo's current renewable sources and its targets are described in the table below, table 6.

Regarding obligatory targets:

The share of Electricity from Renewable Energy Sources in the Gross Final Energy Consumption is foreseen to be 5.66 %. While the share of Renewable electricity in total energy electricity (R.E.S. + other sources of electricity) is foreseen to be 14. 33% and voluntary 25.64%). From the data in 2019, Kosovo achieved 1.8% from the target 5.66% (RE electricity from gross final energy consumption), or 5.14% from the target 14.33% (RE electricity + other sources of electricity – non-renewable). In the report of Eurostat, "other sources" are not described; however, they are not renewable. In Kosovo, coal is the only non-renewable source that is used for electricity by power plants. The amount of R.E.S.- E is relatively low and far from the target, while its production from biomass is non-existent.

Table 6. Renewable energy in Kosovo, achieved and targets, 2019 in ktoe.

Types of energy	Indicators of success	2019 ktoe / (%)	Targets 2020
a) R.E.S.- E	Hydro	23.3 (4.25%)	
	Wind	4 (0.73%)	
	Solar	0.9 (0.16%)	
	Biomass	0 (0)	Mandatory
	Total RES	28.2 **(5.14%)**	**14.33%**
	Electricity generation from all sources (e)	547.9 (100%)	
b) R.E.S.- H&C	Final energy consumption	375.2 (54.55%)	
	Derived Heat	0	
	Heat pumps	0	Mandatory
	Total RES	375.2 **(54.55%)**	**45.65%**
	All fuel consumed for heating and cooling (d)	687.8 (100%)	
c) R.E.S.- T	Ren. Elec. in road-t	0	
Ren-renewable	Ren. Elec. in rail-t	0	
elec- (electricity)	Ren. Elec. in all other- t modes	0	
-t (transport)	Compliant biofuels*	0	

	Non-compliant biofuels	0	Mandatory **10%**
	Other renewable energies	0	
	Total R.E.S.	0 **(0%)**	
	Other Fuels	425.3 (100%)	
	Total (R.E.S. + other)	425.3	
Total (R.E.S.)	(a+b+c)	403.4	
Gross final consumption of energy (G.F.C.E)		1570.6	
Overall R.E.S. share achieved from G.F.C.E	R.E.S.- E = 1.8%; R.E.S.- H&C= 23.89; R.E.S.- T = 0; **Achieved = 25.69%**	Mandatory 5.66% Mandatory 17.24% Mandatory 2.1%	**Overall Target** Mandatory 25.00% Voluntary 29.47%

Source: Author's own construction based on previous studies based on EUROSTAT (2019)& M.E.E. (2021) data

Contribution of Renewable Energy for Heating and Cooling in the G.F.E.C. is foreseen to be 17.24 %; while the share of Renewable Energy for Heating and Cooling in total energy for heating and cooling is predicted to be 45.65%

Heating and Cooling as renewable energy includes: Solar thermal, Biomass, Geothermal, District Heating using R.E.S. and heat pumps. From the table above, we can see that Kosovo meets and exceeds the targets of R.E.S. for heating and cooling, with the main source wood from forests, it is worth mentioning that agriculture residues are not used for heating or any energy production (EUROSTAT 2019; M.E.E. 2021). Furthermore, the surplus of straw is usually burned in fields due to the high costs of collection and baling (ENGLISCH, 2018). Kosovo achieved 23.89 % from the obligatory target of 17.24% (RE heating and cooling from gross final energy consumption), or 54.55 % from the obligatory target of 45.65% (RE heating and cooling from total energy for heating and cooling). The reason for exceeding the target is that Kosovo has plenty of forests; the total territory of Kosovo, 44.7 % or 481.000 ha, are estimated as forest land (TOMTER ET AL., 2013). Due to the high amount of used wood for heating (on average, 85% of urban homes in Kosovo use wood as their main source of heating. Only about 9% of urban homes use electricity for heating, while in villages, wood for heating is 100% (BOWEN ET AL., 2013). District Heating Strategy 2011-2018 of Kosovo specifies that wet lignite and unsustainable fuelwood use for heating purposes must be minimized (M.E.D. 2013). One of the biggest problems is that 40% of public forests and 29% of private forests are subject to uncontrolled and illegal activities use (M.E.D. 2013). Around 58% of wood consumption comes from unregistered logging (W.B.I.F. 2017), explaining the amount the recommended annual harvest for Kosovo is about 1.2 million m3 over bark, the current yearly harvest is 1.6 million m3, almost 0.4 million m3 above the recommended long-term harvest level (TOMTER ET AL., 2013). Based on ENGLISH ET AL. (2015) calculation, to displace the difference of 0.4 million cubic meters, a minimum of 31.4 MW of capacity is required. The high preference for firewood usage in households is continuously increasing, and if it continues at the current consumption rate, Kosovo could have no forests in the future. One of the main drivers of illegal forest-cutting is bad financial situation of the population, especially in rural areas and the lack of affordable and reliable alternative sources of energy (PIRA ET AL., 2011). If this situation would not be enough, the war (1998–1999) resulted in severe damage to the country's natural environment and worsened the decline in education standards (ANDERSSON ET AL., 2001; KURYKIN, 2001). After all these, there is a potential of bared land 20.000 to 30.000 ha of which considerable part is suitable for forestation (M.E.D. 2013).

The contribution of Biofuels (10 % of consumption in the transport sector) will be 2,1 % of G.F.E.C. There are no biofuels applied in the transport section in Kosovo.

The main scheme supporting renewable energy sources in Kosovo is a feed-in tariff. The public energy supplier must pay a regulated tariff for electricity generated from renewable energy sources. A grant support scheme for renewable energy sources implemented in agricultural farms was introduced in 2014 in the annual Rural Development Programme of the Ministry of Agriculture, Forestry and Rural Development (M.A.F.R.D.). After successfully implementing renewable energy sources, farmers are reimbursed 50-60% of the total investment costs within this scheme. Between 2014 and 2019, 1 073 agricultural farms have installed renewable energy sources (mainly photovoltaics) with a full estimated capacity of 3.69 MW (M.E.E. 2021). All electricity produced in these renewable energy sources is intended for own consumption. The producer is not compensated for potential excess electricity production fed into the grid. Electricity production in these sources is reported by the Energy Regulatory Office. However, the Ministry of Economic Development (M.E.E. 2021) states that there is no report; thus, this energy is not counted in the general target. Kosovo’s Fiscal policies and measures from governmental and non-governmental level as well as its supporting scheme, are placed in Annex III

3.4.2 Non-renewable Sources and Air Pollution

According to the Ministry of Economy, “households in Kosovo consume about 40% of electric energy and most of it goes for heating” (NJEKOMB, 2021). Kosovo has a limited energy supply, but it has the largest reserves of coal (lignite) in the Southeastern Europe, which it claims are the second largest in Europe and fifth largest in the world (C.E.E.B.N. 2019) and uses it as the main source of energy production in the form of electricity (97%) (HOXHA ET AL., 2018). Exploitation of mineral sources, respectively coal (lignite) in Kosovo, was estimated to be around 12.5 milliard tons (M.E.S.P. 2010), while the use of coal is around 8 million tons/per year (ASHAK, 2020). The energy sector produces about 82% of total national emissions of GHGs; this sector covers combustion, exploitation and distribution of fossil fuels in Kosovo (AHMETAJ ET AL., 2015). Both power plants, Kosovo A and B emit 5600 tons of CO_2 per year. The annual average emission of particulates is about 9-16 times higher than the allowed average value, while NOx emissions are 34-62% (DRESHAJ ET AL., 2017). Despite this fact, there is only one electricity supplier whose generation market share is 97%; there is no competition in the energy market, while for heating purposes wood is the main source, electricity, coal, natural gas and heavy oil (KABASHI ET AL., 2016). While Montenegro, Serbia, and Albania have eligible customers that may switch their suppliers, respectively 3, 26, and 7, Kosovo is the only country where this eligibility remains theoretical (AHMETAJ ET AL., 2015). A similar situation related to high dependence on non-renewable energy is in Poland, where 90% of electricity comes from fossil fuels. Polish energy policies have encouraged the use of biomass in coal-based power plants in a process called co-firing under the quota obligation and 'green certificate' mechanism, however on the other hand, straw from crops such as wheat, barley, ryegrass, triticale and oats remains the primary biomass type from agricultural activities (IGLIŃSKI ET AL., 2011), and its cost-effectiveness, therefore, will continue to be large and critically dependent on biomass producers' (farmers) willingness to supply biomass at competitive prices (ALTMAN ET AL., 2015; ALTMAN & SANDERS, 2012). An interesting finding was in the study of ZYADIN ET AL. (2017), who compared the willingness of farmers to sell straw in two regions, farmers who were living in the coal-rich region were more willing to supply biomass (37% willingness) compared to those farmers who had their farms in the renewable energy-driven province (16% willingness to collect), these motives can be influenced by availability of coal for domestic use, small land acquisitions, and juxtaposition to coal-based power plants.

Coal Electricity prices

After Ukraine, households' electricity price in Kosovo is the lowest in Europe with 6.05€ per 100kwh, without taxes and levies, the price is 5.25 while in E.U. countries, the average price was €21.26 per 100 kWh while without taxes and levies the price was 12.69 per 100kWh (figure 7) (EUROSTAT, 2020B). Across the E.U. Member States, household electricity prices in the first half of 2020 ranged from below €10 per 100 kWh in Bulgaria to more than €30 per 100 kWh in Denmark and Germany (EUROSTAT, 2020B). A major problem with coal in Kosovo is that its total cost is not reflected in its market price, and thus while we may seemingly purchase and burn coal cheaply, in reality; we are paying a much higher cost in the long run. Those who benefit from the seemingly cheap electricity do not pay for these externalities directly, but the public eventually has to pay in the form of medical bills, environmental cleanups, etc. (AHMETAJ ET AL. 2015).

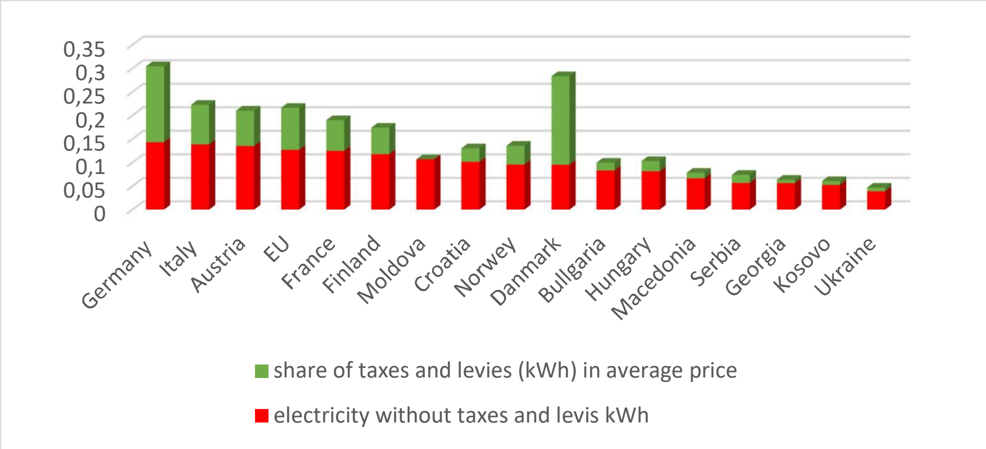


Figure 7. Electricity prices (€) for household consumers, 2020
Source: Author's own construction based on previous studies based on EUROSTAT (2020*B*) data.

Despite this fact, if the living standard and purchasing power parity are included in the comparison model, it comes out that Kosovo citizens pay on average 52% more for electricity compared to citizens of any other country from the region or E.U. Factors such as depreciation of capital, foreign investment in the form of grants, government subsidies to the energy sector, lack of investment in environmental protection and cheap labour force have reduced electricity prices so far. In general, they should keep the price low (R.E.C. 2009).

3.4.3 The Role of the Agriculture Sector in Kosovo's Economy

Kosovo is divided into two valleys, Kosovo and Dukagjini, both irrigated by rivers that sustain agriculture (LIMANI, 2020) and have different soil structures and climates (RKS-GOV, 2021). From the total land area, the share of forest land is the highest, 44.7%, followed by cropland 28.7% and grassland 15% (M.A.F.R.D. 2012). According to BYTYÇI & GJERGJIZI (2015), most farms are oriented within household in Kosovo. The largest agricultural holdings are farm size 0 up to less than 5 ha (75.3%). Most of the agricultural work in the Agricultural Households is carried out by family workforce. Managers (mainly the same persons as the carriers) carry almost half of the agricultural work (44.6%), while other family members carry out the other half of the job. Seasonal workers contribute only 2.8%. The level of education of holders is relatively low. As far as education/training in agriculture is concerned, more than 95% of managers have only practical experience in agriculture (A.S.K. 2014). Support of the Government by subsidizing this sector by grants and direct payments is continuing. In the agriculture sector budget, wheat has the highest share because the total area with crops is 124,199ha, and wheat is cultivated in most of the area land 64.4%, maize 31.8%, and others. The total domestic production of wheat was 284,999 tons which cover 57% of the domestic consumption needs, and imports cover the rest; this is the lowest rate of self-sufficiency since 2016 (69.9%). Farmers with more than 2ha of wheat benefited 150 €/ha, and those with more than 5 ha also benefited direct payments for seeds 250 €/ha (M.A.F.R.D. 2020). However, the area cultivated with wheat is decreasing year by year. When it comes to price, 2019 was the highest 0.21 euro /kg (at the farm) compared with other years 2017-2018 (0.16 euro/kg). In Kosovo, most of the wheat is used for human consumption as flour, and the rest is sold and used for animal feed (M.A.F.R.D. 2020). Based on F.A.O. information, for every 1.3 kg of wheat grain produced, about 1 kg of straw is produced (RUIZ ET AL., 2012). According to a study in Kosovo conducted by SAHITI ET AL. (2015), the ratio straw/grain was calculated 1:1, which means in 2019, from the total production of wheat yield 284,999 tons, it can be produced 284,999 ton straw. However, these measures are statistical because there are different cultivars of wheat and taking into account different climatic conditions, the amount of residues can change by region. The support from the government to agriculture is also aimed at preventing migration of the population in the absence of jobs and prospects for a better life in these areas, knowing that investments in agriculture and other non-agricultural activities can generate new jobs (M.A.F.R.D. 2017).

4 METERIALS AND METHODS

The methodology of the study is divided into three sections with its corresponding analysis, which are described in table 7.

Table 7. The description of the methodology

Topics analyzed	Methods used
The impact of non-farm incomes on equity	Descriptive analysis, One-way ANOVA, poverty decomposition techniques- Foster, Greer, and Thorbecke (FGT)
Farmers' Attitudes towards the Use of Biomass as Renewable Energy	Descriptive analysis, Binary logistic regression
The experiment of three winter wheat cultivars	One-way ANOVA, Correlation, t-test

Source: Author's own construction

4.1.1 Sampling Procedure/Techniques and Sample Size

Kosovo is divided into seven regions and 38 municipalities LATIFI-PUPOVCI ET AL. (2020). Our samples were chosen based on the willingness of farmers to cooperate. Due to the absence of knowledge in using the internet among farmers, the questionnaires were hand-filled. The researcher collected primary data through face-to-face interviews by making personal visits to rural areas, both at home and the workplace of respondents and in one of the mills. Before beginning the interview, each respondent was given a brief idea about the nature and purpose of the study, explaining that it would be used solely for academic research purposes. Both closed and open questions were included in the interviews, and all answers were recorded carefully. The questionnaires were firstly pretested with a sample size of 10. It is important to note that the study sample can be considered statistically representative at the national level because of the data collection methods used. The sample adequacy tests showed that the sample chosen for the study is adequate at a 95% confidence level with a margin of error of 6.8% and 6.7% for the first and second study.

- The first study was conducted during spring of 2017. Our sample area consisted of five regions and seven municipalities within those regions. The sample sizes of the five regions were: 31; 38; 57; 51, and 26 (number of questionnaires distributed). In total, the survey covered 203 heads of farm households. Farmers engaged in cultivation of various vegetables, small fruits and crops were chosen using a random sampling technique. The applied structured questionnaire contained several customised modules capturing, among other things, farming activities, all sources of income, and driving forces of income diversification. Our research highlights the effect of non-farm income on poverty and inequality of household income.
- Collection of data for the second study was done during the period May–October 2019. The sample consists of six regions and four municipalities within the regions. The sample sizes of the six regions were: 58; 56; 50; 20; 11; and 11 (number of questionnaires distributed). Municipalities were selected throughout Kosovo at a distance of up to 70 km from an energy plant site, a similar distance we can find in the study of GIANNOCCARO (2017), as Kosovo does not have any official strategic plan on the transportation cost and distance for straw as bioenergy. There are only two power plants, Kosova A and Kosova B in the vicinity of the capital, that produce electricity from coal lignite; we can also consider the role that pellet producers can have in terms of straw distribution. There is also one region that has its own District Heating.

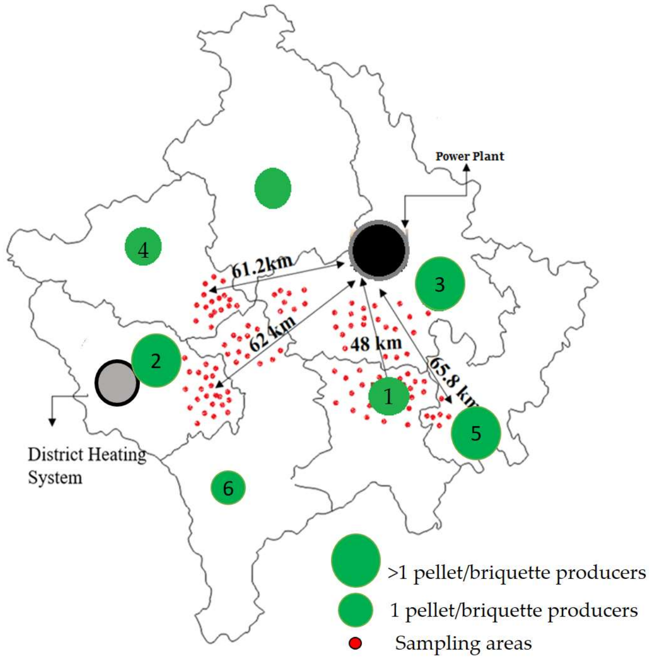


Figure 8. Kosovo map, and sempling, pellet producers and district heating locations
Source: Author's own construction

In figure 8, are described six regions with different numbers based on sample size: In region number one, 58 questionnaires were conducted, region number two had 56 questionnaires. Region number three, 50 questionnaires, and in regions number 4, 5 and 6, we included only one municipality per region with the following sample size: 19, 11, 11 questionnaires consecutively. Based on secondary data (KRAJNC ET AL., 2015) and research for pellet producers on the internet, every region has one/more pellet or briquette producers, which are seen as potential market players, where farmers can send their straw. Note that for ethical reasons, green spots do not represent the exact number and location of producers. The questionnaire contained questions regarding socio-economic factors, farm profile, practice of using straw, and their willingness to sell straw. After they were distributed to 230 farmers in country and 206 farmers responded (response rate: 89.57%). We consider that the sample in the study is statistically representative at the national level because of data collection methods used.

- Third study is done through experiment; After discussing with different agricultural pharmacies in two main regions in Kosovo, we selected three most used wheat cultivars. A similar selection based on their wide use was chosen in the study of DUBS ET AL. (2018). The three winter wheat cultivars: *Euclid*, *Vulcan* and *Exotic*. The experiment with three cultivars of wheat was conducted during the years 2018/2019 for the first experiment, and it was repeated during 2019/2020 as the second experiment in two main reagions of Kosovo; Dukagjini Plain and Kosovo Plain

4.1.2 Data Analysis

In order to analyse inequalities or differences within our sample, between the poorest and the richest, the total sample was separated into three income classes (tertile) based on respondents' incomes. To determine the significance level, these three variables (tertile) are compared with each other in terms of socio-economic factors, using one-way ANOVA (Tukey method) in Minitab 17. A similar methodology for analysing the significant differences between three variables are used in different studies elsewhere (MÖLLERS & BUCHENRIEDER, 2011; YMERI ET AL., 2017). Furthermore, farms were divided based on farm type to understand better the link between the level of farmers' engagement in agriculture and their income. According to MÖLLERS & BUCHENRIEDER (2011), full-time farms are characterised by only 10% income coming from non-farm sources, the second type of farms (complemented part-time farming) have a share of non-farm incomes between 10%-50%, and the third type of farms with more than 50% of income from non-farm sources are considered as subsidiary part-time farming. These three types of farms are considered as independent variables.

For the second study, data was examined with a statistical package for social sciences (SPSS 19). Descriptive statistics were used to describe the gathered data and variables. Binary logistic regression was used to check significant factors influencing the percentage of straw that farmers are willing to sell to a power plant, similar method with the willingness was used in the study of MURIQI ET AL. (2019).

While for the third study, all the data are calculated through statistical programs (SPSS 19). One-way ANOVA (Tukey test) was used to test differences between cultivars within the region, independent sample t-test was used to analyze differences of wheat cultivars between regions and years, while Pearson Correlation was used to figure out the link between wheat parameters; total dry biomass, chaff and seed (in gram), height of pant, height of spike and height if straw.

4.1.3 Measurement of Poverty

To examine the impact of non-farm income on poverty, we used poverty decomposition techniques- Foster, Greer, and Thorbecke (FGT) , as has been done by MÖLLERS & BUCHENRIEDER (2011). The modified version of the index created by Foster-Greer-Thorbecke (FOSTER ET AL., 1984) can be used to observe the effects of nonagricultural income on poverty. As (MAT ET AL., 2012)used the index mentioned above to see the effect of sources of income on poverty in Kedah (Malaysia), while IQBAL ET AL. (2018) used the same index to analyse the effect of non-farm income on poverty in Punjab (Pakistan). ZHU & LUO (2005) applied this index in their research in rural China, while OGUNDIPE ET AL. (2019) used the index to assess the gender differential in poverty (captured through incidence, depth, and severity). This index was used in other studies as well (ARISTONDO, 2018; AWOTIDE, 2012). Hence, we consider three versions of the income poverty index to shed more light on different aspects of income poverty (1) the headcount index, (2) the poverty deficit index, and (3) the poverty severity index. According to FOSTER ET AL., (1984), the three poverty measures are explained by (2)

$$P(\alpha) = \frac{1}{n}\sum_{i=1}^{m}\left[max\left(\frac{z-ci}{z}\right),0\right]^{\alpha} \qquad (2)$$

where z is the poverty line, ci is the income of the individual i, n is the total number of individuals, and m represents the number of poor individuals. In terms of poverty measures, the parameter α can change. P(0) displays the headcount index, which signifies the share of poor individuals below the poverty line, where parameter α is determined to be equal to 0, we obtain P (0). When parameter α is determined to be 1, we obtain P (1) that is the poverty deficit; this measure considers how far the poor, on average, fall below the poverty line. Lastly, poverty severity measures if α is equal to 2, we obtain P (2), which takes into account the difference in the severity of poverty by giving more weight to the poorest or taking into account the inequality among the poor. Therefore, poverty severity finds income differences better. A poverty risk index is compiled by comparing poverty measures of certain groups of a population concerning the total population (WORLD BANK, 2000). The international poverty line, which the World Bank recommended, was used as a measure of absolute poverty. We also present a relative poverty line that corresponds to 60% of the sample's median equivalised per capita income (OECD, 2017). MÖLLERS & BUCHENRIEDER (2011) declare that poverty analyses generally are related to equivalised household sizes. With each additional member of a family, the demands of a household grow but not equally as a result of economies of scale in consumption. Demands for electricity, housing space, etc., will not be three times higher for a household with three members compared with a single person. According to ATKINSON ET AL. (1995), equivalence scales can help determine a value for each household type, which is in proportion to its needs. To estimate equivalence scales, we can find three methods: Here, we use a class of equivalence scales which can be described by the following formula: (3)

$$Equivalent\ size = (Adults + Children)^{\theta} \qquad (3)$$

where θ is a parameter between 0 and 1 to be chosen or estimated. We set the equivalence scale θ to 0.53. The following equivalence number for normal household sizes is too close to what is called the OECD-II equivalence scale[1].

[1] "OECD-modified scale." After having used the "old OECD scale" in the 1980s and the earlier 1990s, the Statistical Office of the European Union (EUROSTAT) adopted in the late 1990s the so-called "OECD-modified equivalence scale." This scale, first

4.1.4 Measurement of Inequality

According to SHKOLNIKOV ET AL. (2003), the widely known and used measure of inequality is the Gini coefficient, which relies on the Lorenz curve; this curve represents a cumulative frequency curve. It compares the share of a specific variable (for example, income) over the population to show inequality. Another Gini is calculated based on how a source of income decreases/increases the overall Gini coefficient. The Gini coefficient lies between 0 and 1, with 0 signifying absolute equality and 1 meaning absolute inequality (MÖLLERS & BUCHENRIEDER, 2011; WORLD BANK, 2000).

4.1.5 Binary Logistic Regression

In regard to the analysis with the willingness of farmers to sell straw, binary logistic regression is used. This is sometimes called the logistic model or logit model and it analyses the association among multiple independent variables and a categorical dependent variable and estimates the likelihood of occurrence of an event by suitable data to a logistic curve (PARK, 2013). Using this model, factors (X–independent variables) affecting the percentage of straw willingness to sell, and results (Y–dependent variables) could be measured. The formula used for this analysis is as follows:

$Y = B_0 + B_1\,Already\ sell\ straw + B_2 Soil\ Concerns + B_3 Presence\ of\ animals + B_4 Engagement\ in\ Agriculture + B_5\ Age + B_6\ Farm\ size\ with\ wheat + B_7 Farm\ type + B_8 Employment + B_9 Education + B_{10} Percentage\ of\ willing\ to\ sell\ corn + B_{11} Farm\ size\ with\ corn + B_{12} Family\ size + ui.$

In regard to the percentage of selling straw, almost all farmers had a refereeing point of 50% (less or more than 50%). For example, 113 (54.9%) farmers are willing to sell straw more than 50% for energy purposes. While the other part of respondents, 93 (45.1%), are willing to sell straw less than 50%. For this reason, we decided to separate farmers into two groups and check different variables which influenced the amount of willingness to sell straw, the model is described as follows: Percentage of willingness to sell was involved as the binary dependent variable [(0) less than 50%; (1) more than 50%]. Twelve variables were included in the model (Table 16) using the Enter Method: I. Sell straw on the market [(0) not selling straw; (1) already selling straw]; II. Soil Concerns [(0) not incorporated; (1) incorporated into the soil]; III. Presence of animals [(0) do not have animals; (1) have animals]; IV. Engaged in agriculture [(0) part-time farmer; (1) full time farmer]; V. Age of farmer: [(0) 20-40 year old; (1) > 41 year old]; VI. Farm size with wheat: based

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proposed by (Haagenars et al. 1994), assigns a value of 1 to the household head, of 0.5 to each additional adult member and of 0.3 to each child (OECD, 2015) on hectares per farm [(0) 0.01-9.99ha; (1) > 10ha] VII. Farm type [(0) wheat; (1) wheat and corn]; VIII. Employment [(0) outside agriculture; (1) agriculture]; IX Education [(0) Elementary/higher school; (1) University] X. Percentage of willing to sell corn [(0) not planning to plant corn; (1) <50%; (2) >50%]; XI. Farm size with corn [(0) 0-9.99ha; (1) >10ha]. XII. Family size [(0) 1-9 members; (1) >10 member].

4.1.6 Field Experiment

After discussing with different agricultural pharmacies in two regions, we selected farmers' that most used wheat cultivars. A similar selection based on their wide use was chosen in the study of DUBS ET AL. (2018). There were three winter cultivars: *Euclid* from France, *Vulcan* from Croatia and *Exotic* from Romania. The experiment with three cultivars of wheat was conducted during the years 2018/2019 for the first experiment, and it was repeated during 2019/2020 as the second experiment. However, in the result section, the experiment during the period 2018/2019 is referred to as the experiment in 2019, while the experiment during the period 2019/2020 is referred to as the experiment in 2020. Plots were sown and harvested on the following dates (table 8). A similar methodology was repeated for the second year.

Table 8. Sown and Harvested Date of Wheat Plants.

Region	Dukagjini Plain		Kosovo Plain	
Years	2018/2019	2019/2020	2018/2019	2019/2020
Sown date	19.10.2018	21.10.2019	26.10.2018	23.10.2019
Harvest date	12.07.2019	10.07.2020	16.07.2019	15.07.2020

Source: authors' own construction

The research was conducted in two different agro-climatic and terrestrial regions of the Republic of Kosovo (in the Dukagjini Plain and the Kosovo Plain) (Figure 9). Test fields were planted on the experimental farms of the Kosovo Agricultural Institute, in the Dukagjini plain (Vitomirica/Peja), in the Kosovo plain (test fields were planted in Lipjan). Kosovo Plain is influenced by continental air mass with an average temperature of -10 ^{0}C during winter, whereas summers are very hot with an average temperature of 20^{0}C. The annual precipitation in the Kosovo Plain is estimated to be 600mm. Dukagjin Plain is highly influenced by hot air masses that go through the Adriatic Sea. The average temperature during the wintertime is 0.5^{0}C to 22.8^{0}C. The average annual precipitation of this climatic area is 700mm (RKS-GOV, 2021). The weather for the growing season is given in Fig. 8; there was low rainfall throughout the growing season, but especially in spring.

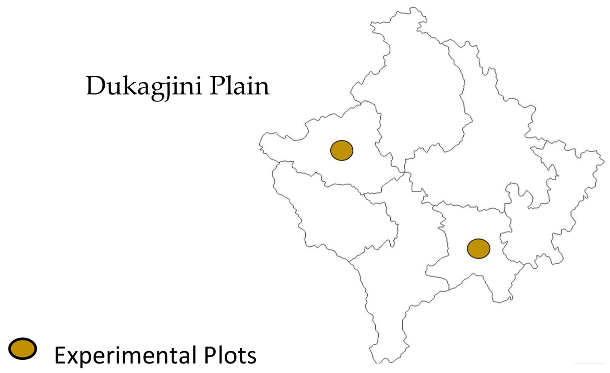
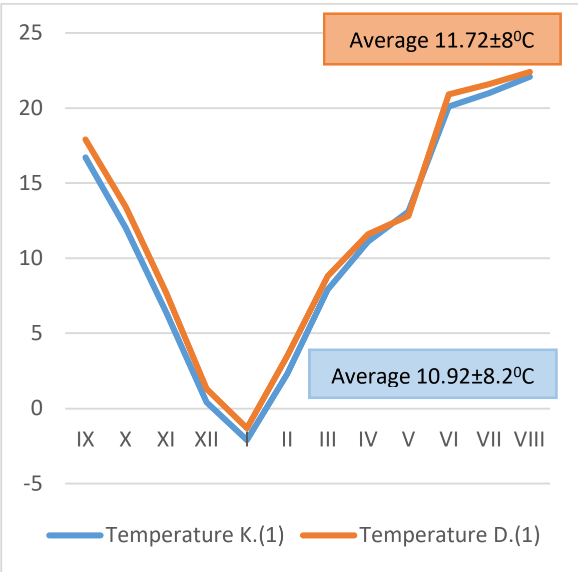


Figure 9. Kosovo Map and Location of Experimental Plots
Source: Author's own construction



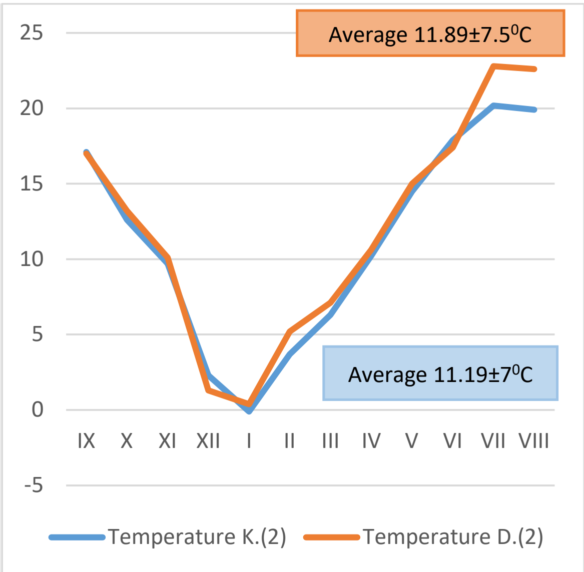


Figure 10a) Monthly Temperature °C, (2018/2019) **Figure 11b) Monthly Temperature °C,(2019/2020)**
Source: Author's own construction based on previous studies based on IHK (2020) data

Figure 10) represent the monthly average temperature (C^0) during the first year experiment, and it is shown from September 2018 to August 2019 in two regions. The blue line is for the Kosovo Plain, and the orange line is for the Dukagjini Plain. From the graf, we can see that the average temperature in the Dukagjini plain is slightly higher than in the Kosovo plain.

Figure 11) shows the monthly average temperature (C^0) for the second year of the experiment and the months from September 2019 until August 2020. Again the blue line represents the Kosovo Plain, while the orange line is for the Dukagjini Plain. Similar to the previous experiment, the average temperature is slightly higher in the Dukagjini plain than in the Kosovo Plain.

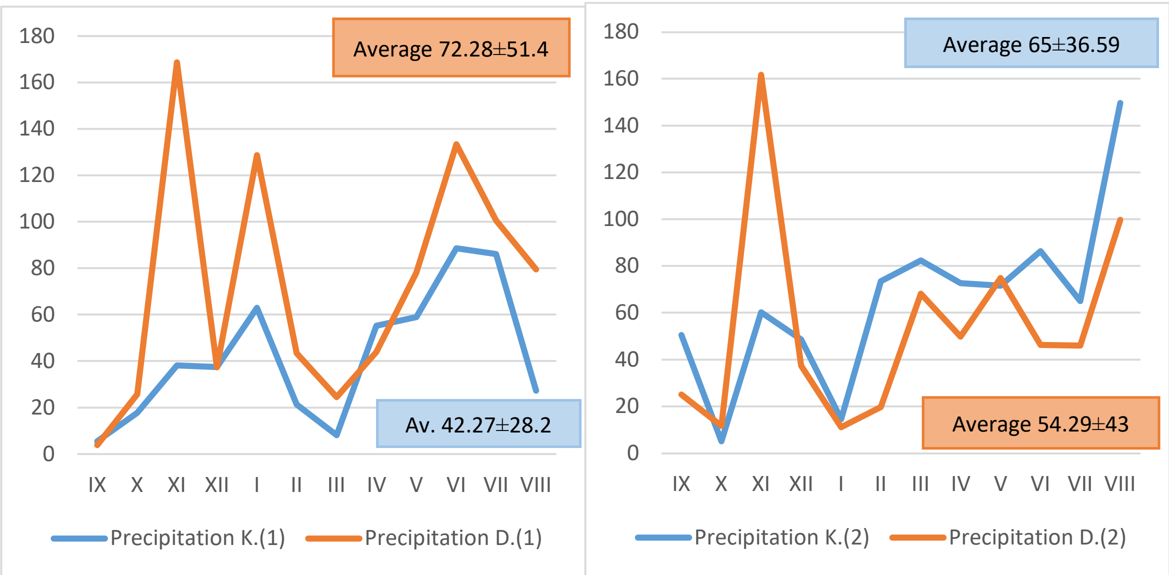


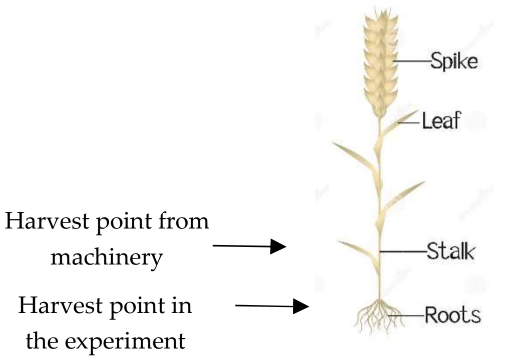
Figure 12a)Monthly Precipitations mm(2018/2019); Figure 13b) Monthly Precipitations mm(2019/2020)
Source: Author's own construction based on previous studies based on IHK (2020) data

Figure 12) represents the average monthly precipitation (mm) during the first year of the experiment, and it is shown from September 2018 to August 2019 in two regions. The blue line is for the Kosovo Plain, and the orange line is for the Dukagjini Plain. From the graf, we can see that the average precipitation in the Dukagjini plain is slightly higher than the Kosovo plain.

Figure 13) shows the average monthly precipitation for the second year of the experiment from September 2019 until August 2020. Again the blue line represents the Kosovo Plain, while the orange line is for the Dukagjini Plain. Contrary to the previous experiment, the average precipitation is slightly higher in the Kosovo plain than in the Dukagjini Plain; however, from October until December, we can see higher precipitation in the Dukagjini plain, this trend decreased for the following months.

4.1.7 Experimental Plot Design

The experiment is conducted according to a plan with three repetitions (R1, R2, R3) per each cultivar (see in figure 9) in two regions; a similar methodology with three repetitions was applied in the study of (DAI ET AL., 2016; DUBS ET AL., 2018). During this phase, all physiological, meteorological and terrestrial factors are measured. Each experimental unit contained one entry and was managed using appropriate production practices to maximise grain yield. Standard practices for fertilisers and pesticides were used, the schedule of inputs and management practices used in two experiments are given in Appendix II. This study includes the analysis of yield/residue report in g/plant similar with (SPANIC ET AL., 2017), differences between two years within a region and two regions within a year based on yield, total dry biomass (straw which is harvested 2cm above ground, chaff and leaves), collectable biomass residue (straw which is harvested 15cm above ground without stubble and chaff) gram/plant and kg/ha also length of straw and spike in cm per wheat plant. The share in (%) of each parameter (from dry biomass) was found within a wheat plant. Harvesting machinery cuts wheat around 15 cm above ground; in our experiment, there are two harvesting points, the first one was around 2cm above ground, and the second 15cm above ground. We measured 13cm of straw in gram as stubble (2 cm on land + 13cm above the ground= 15 cm) in order to see the quantity of straw if it is harvested as usually by farmers and the quantity of total dry biomass (2 cm of straw above ground + roots are not measured in gram as biomass)



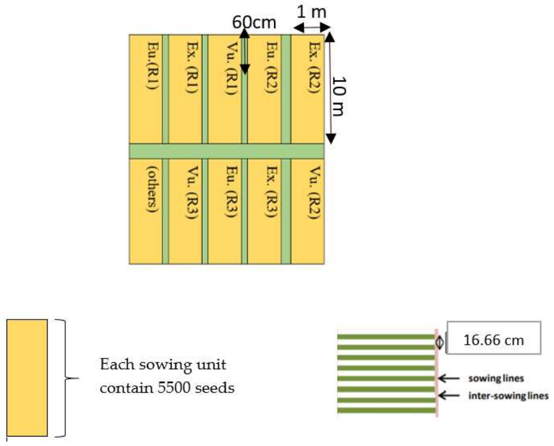


Figure 14. Harvest point (2cm and 15cm above the ground); Figure 15.Experimental Plot design

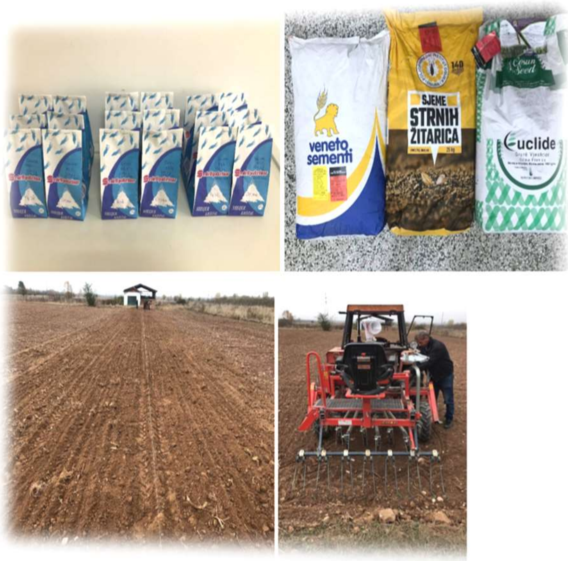


Figure 16. Field Experiment
Source: Author’s own construction

Each plot had 550 seeds/m2, which weigh differently, depending on the cultivars, for example, *Euclid* 550 seeds/m2, 227.6 gram; *Vulcan*, 550 seeds/ m^2, 194.2 gram and *Exotic*, 550 seeds/m2, 285.1 gram. Each cell represents a specific sized area with a certain cultivar of wheat. Each of the three cultivars is planted three times in a certain field (in different cells, according to figure 2.), experimental design with three replication can be found in different studies (DAI ET AL., 2016; DUBS ET AL., 2018). From each plot, 30 wheat plants were chosen randomly and measured. After harvest, the number of plants was counted per plot on the size of $1m^2$. Plots were of identical size and divided into nine sowing units of 1 m x 10 m in each region. Plantings are realised with a special machine, called Hege machine type 80. A seedbed was prepared by ploughing (20-30 cm deep), each sowing unit consisted of six (6) sowing lines spaced from each other, leaving a 16.66 cm gap, each plot was spaced from each other, leaving 60 cm wide row to standardise plot edge and possibly limit dispersal of pathogen spores between neighbouring plots (Fig. 9). Moisture content of either grain or straw was recorded at the time of harvest, which was between 10.6% and 11.8%, samples at all locations were taken at the time the wheat crop was harvest ripe or Zadoks growth stage 93 similar with (DAI ET AL., 2016; ZADOKS ET AL., 1974), we also left plants to dry for 2-3 weeks in an building with open windows, keeping them dry, according to DAI ET AL. (2016) both wheat grain and straw can be stored indefinitely at ambient temperatures at standard moisture content and are not subject to spoilage as long as samples are kept dry. According to DAI ET AL. (2016), grain moisture content at harvest ripe is between 10.6% and 17% by weight, as standard moisture content for wheat is 13.29% moisture. Similar moisture content can be found in different studies (DAI ET AL., 2016; DUGGAL ET AL., 1980; PFOST ET AL., 1976). During the research, field and laboratory parameters were evaluated, which were realised in different phenophases during vegetation and after harvest of experimental wheat fields. During the research, several different activities were carried out: 1) soil sampling and their analysis, which were carried out by the Laboratory of Soils, Fertilizers and Irrigation Water. 2) Plant health analyses and recommendations for treatments were performed by the National Reference Laboratory for Plant Protection, while various physical and chemical analyses were performed at the National Reference Laboratory for Quality and Seed Certification. In this case, the research project has been implemented and monitored by the Crop Production Sector in cooperation with the laboratories mentioned above, which operate within the Agricultural Institute of Kosovo in two regions (Dukagjini Plain and Kosovo Plain).

Harvest index and **the ratio of straw to grain** are calculated based on formulas below:

1) $HI = \frac{Grain\ Yield}{Biological\ Yield} x\ 100 = \frac{Grain\ Yield}{(Grain\ Yeild + Stra\quad Yield*)} x\ 100$

2) $Ratio = \frac{Straw\ Yeild}{Grain\ Yield}$

*Straw yield here represents the total dry biomass

3) $Ratio.C = \frac{Collectable\ Straw\ Yield}{Grain\ Yield}$

4) $Ratio.C.W = \frac{Collectable\ Straw\ Yield}{Grain\ Yield} x\ willingness\ to\ sell\ the\ straw(\%)$

Ratio C= collectable amount of straw to grain ratio
Ratio C. W=collectable amount of straw to grain (based on willingness to sell straw in percentage) ratio

(1) The HI value was obtained by dividing grain yield by the aboveground biomass of the sample (Dai et al., 2016), (2) The ratio straw to grain was obtained by dividing the total dry biomass by grain yield, (3) The ratio straw to grain was obtained by dividing the collectable amount of straw by grain yield, (4) The ratio straw to grain was obtained by multiplying the collectable amount of straw with the percentage of farmers' willingness to sell collectable straw amount of straw means (straw 15cm above the ground, without chaff), we added the % of willingness of farmers to sell straw, which means from the amount that is collectable farmers want to sell it in different percentages (for energy purposes) as they also use it for other purposes.

5 RESULTS AND DISCUSSION

5.1 Incomes of farm households

With per capita GDP estimates of close to €3,000, Kosovo is one of the poorest countries in Europe. Average per capita income is about one-tenth of E.U. levels, and poverty remains high. No significant differences exist between urban and rural poverty, but there are some notable regional differences (WORLD BANK, 2016). However, from table 9 (per capita incomes), it is clear that rural incomes are considerably lower than this national average. The income portfolio of family farms contains three main categories, the largest of which, at 73.57%, is farming income, while non-farm income makes up a share of 21.29%. Remaining income refers to so-called unearned income and consists of social transfers, migration, and pensions (5.14%). We can find similar results from authors DEMISSIE & LEGESSE (2013), where agricultural activities contribute 77% of total household income and 23% from non-agricultural operations.

Table 9. Income of Farm Households in Kosovo, 2017

Income	Total average
Per capita income (€)	1868.80
Per capita income, equivalent scale (€)	4409.81
Household income (€)	12362.78
- Farm income (%)	73.57
- Non-farm income (%)	21.29
- Unearned income (%)	5.14

Notes: The average household size in the sample is 7.8 persons.
Source: authors' own calculation, N=203 farm households

5.1.1 Assessment of Socio-Economic Differences According to Income Classes

In order to test for socio-economic differences among respondents in their income classes (tertiles), from the poorest to the wealthiest under study, a one-way ANOVA using the Tukey test was done.

Similar methodology of separating the sample into three groups (tertiles) is done in the study of MÖLLERS & BUCHENRIEDER (2011). Results are given in Table 10, where we can find that non-farm income and per hectare income make a difference regarding the overall economic well-being. The poorest group had the highest share of farm income (77.52%), with the lowest share of other income sources being just 22.48% giving non-farm income and unearned income value of $p<0.05$. While the highest farming income per hectare has the wealthiest group $p<0.05$, their farm income share is 74.73%, and income from other sources is 25.27%. Overall, these structural differences in income shares in the wealthiest group are significant compared with the poorest group. The wealthiest tertiles (2 and 3) are characterized by a higher share of education, household size, off-farm income, and younger households than the first group. The results of DEMISSIE & LEGESSE (2013) showed that the number of children, number of economically active family members, gender, education, and age of household heads are strongly associated with non-farm income employment decisions.

Table 10. Socio-Economic Characteristics According to Income Classes, 2017

	Income class (tertile)			**All House.**	**Test statistics**
	1	2	3		p-value
Household income (€)	3726.47^{c}	8477.17^{b}	24827.54^{a}	12362.78	0.000
Per capita income, equivalent scale (€)	1467.72^{c}	3166.92^{b}	8576.51^{a}	4409.81	0.000
Median of per capita income (€), equivalent scale	1432.511	2989.543	7310.151	3910.74	
Share in all household incomes (%)	11.15	23.70	65.15	100	
Income shares (%)					
- Farm income	77.52^{c}	68.36^{b}	74.73^{a}	73.57	0.000
- Non-farm income	20.50^{b}	26.04^{b}	19.81^{a}	21.29	0.000
- Unearned income	1.98^{b}	5.60^{ab}	5.46^{a}	5.14	0.026
- Nonfarm + Unearned income	22.48	31.64	25.27		
Farmland (ha)	4.30^{b}	4.38^{b}	7.72^{a}	5.47	0.000
Farm income per ha average(€/ha)	1363.01^{c}	2742.81^{b}	3756.62^{a}	2620.21	0.000
The education level of household head (%)					
Lower than elementary	1.47	1.49	0.00	0.99	0.607
Elementary school	26.47	20.90	14.71	20.69	0.319
Agricultural high school	2.94	8.96	2.94	4.93	0.202

Other secondary schools	55.88	46.27	58.82	53.69	0.541
University	13.24	22.39	23.53	19.70	0.341
Age of household head	49.31[a]	45.01[a]	45.91[a]	46.75	0.109
Household size	7.12[a]	7.75[a]	8.54[a]	7.80	0.155
Children under 18	2.19[a]	2.55[a]	2.60[a]	2.45	0.541

Means that do not share a letter are significantly different

Source: authors' own calculation

5.1.2 Distribution of Non-Farm Incomes Based on Income Level of Rural Households

The study has analyzed the relationship between income level and distribution of off-farm income sources in total households' income. Contrary to the expected decreasing or u-shaped curves, the higher level of non-farm incomes in the middle-income class leads to an inversely shaped u-curve. The poorest group, with around 22%, belongs to a moderately low degree of non-farm income (described in figure 17). Generally, poorer households have high motivation but low ability to be involved in other sources of income; BARRETT ET AL. (2001) has discussed this case. We can also see the percentage of migration, which is the lowest in the poorer households and is in line with different studies (MCKENZIE, 2017; MENDOLA, 2008). Again if we analyze middle-income class, we see that non-farm income sources increases total income, therefore, it might be a distress-push situation as the reason for the inverse u-shaped relationship. In this situation, access to non-farm employment is easier or more difficult for certain parts of the population. Simultaneously, farming is seen as the most profitable solution for rural households compared to all other sources of income. Middle-income households appear to be defined by their potential and skills to find other options in the non-farm activities, enabling them to increase their total income and compensate for low farming income. While tertile 3 (a group with the highest income) has significantly higher income per hectare than both groups, and it is less engaged in agriculture compared to the poorest group as it is described on table 10.

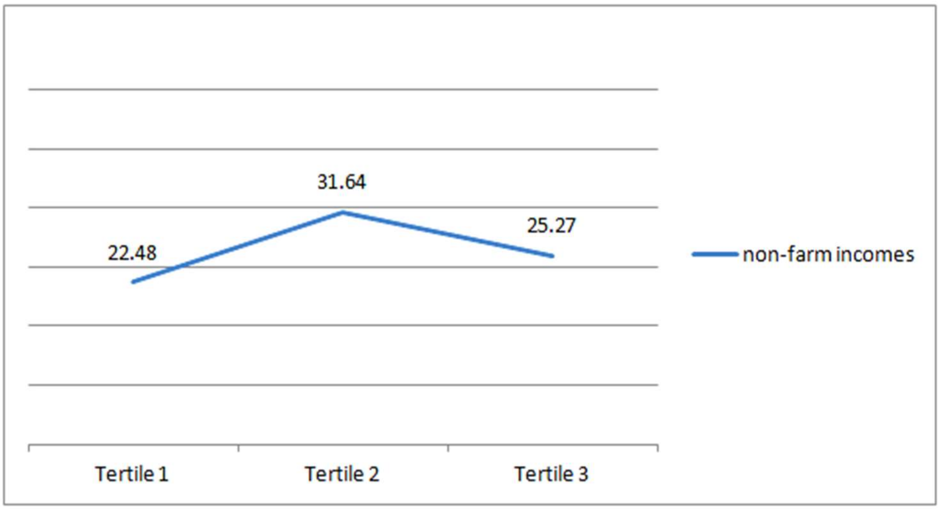


Figure 17. Income Groups and Share of Non-farm Incomes (%)
Source: authors' own calculation

5.1.3 Level of Farmers' Engagement on Agriculture

Farmers are engaged in agriculture on different levels; based on these levels, farm type is created. According to MÖLLERS & BUCHENRIEDER (2011), from the total income of full time farms, only 10% are from non-farm sources, while the second type of farms (complemented part-time farming) have a share of non-farm income between 10%-50% and the last one subsidiary part-time farming is as a typical subsidiary farm where the head of household gives priority working outside the farm sector and as a result, non-farm income is higher than farm income (part-time farms, subsidiary). The study analyzes farmers' incomes based on farm types (table 11). The results show that complemented part-time farming (type 2) fares better compared to per capita incomes $p>0.05$. This difference may be explained because farm income per hectare of land on type 2 is the highest. Nonetheless, this farm income per land on type 2 farms is not significant, another explanation may be due to high share of non-farming income compared to full-time farms $p<0.05$. According to per capita income, full-time farms are the poorest, even though they have higher income per ha than subsidiary farm types. Full-time farms disadvantage remains on the lowest share of non-farm income $p<0.05$, thus non-farm income sources are essential, and it seems that alternative employment can increase income.

Table 11. Incomes According to Farm Type Classes in Kosovo, 2017

Farm type (N)	Per capita income, equivalent scale (€)	Farm income per ha of land (€/ha)	Nonfarm income per capita eq. scale (€)	Farm share In total income (%)
Full-time farms (99)	3997[a]	2601.71[a]	29.7[c]	99.2
Complemented part-time farming (63)	5165[a]	3001.98[a]	1923[b]	62.32
Subsidiary part-time farming (40)	4223[a]	2055.17[a]	2909[a]	31.59
p-value	0.182	0.167	0.000	0.456

Means that do not share a letter are significantly different
Source: authors' own calculation

Based on the finding of MÖLLERS & BUCHENRIEDER (2011), full-time farms had a share in the total income of around 68.1%, and per capita incomes of full-time farms fared the best compare with the other two types of farms. The same author MÖLLERS & BUCHENRIEDER, (2011) stated that this could be due to a higher share of farming income and higher productivity. In our case, usually, farmers had more than 10% share from non-farm incomes or not a share at all. As a result, full-time farms were fully engaged or had a farm share in the total income of 99.2%, with significantly low non-farm income, these type of farms also had lowest income per capita and lower income per ha compared to complemented part-time farming.

5.1.4 Poverty incidence and income distribution

The poverty incidence of rural households is shown in Table 12. The headcount index calculated based on a USD 4.30 poverty line (JIMENO ET AL., 2000) results in that 20% of the farm households in the sample face absolute poverty. Based on the results, almost one quarter (24%) of the households' sample falls below relative poverty line. Poverty severity, this indicator shows relatively low figures for the sample households, meaning that there is no considerable inequality in income distribution amongst the poor. The poverty gap index measures the total difference between the actual incomes of poor households and the poverty line. This index shows how much money should be transferred to the poor to lift them out of poverty (REINERT, 2017). The poverty deficit, defined as the average distance of the poor to the relative poverty line, is relatively low at 9%. In our sample, a household can be lifted above the relative poverty line with an additional 489.79 € per year and above the absolute poverty line with 316.42€. According to the impact that non-farm income and unearned income have, non-farm income lifts 16% of households out of poverty. The effect of unearned income is lower by about 2.7%-3.45%.

Table 12. Poverty Incidence and Income Distribution

	Household Yearly income (€)	Headcount -index	Poverty Severity	Poverty Deficit (Gap)	The share of households shifted above poverty line due to	
					Non-farm Income	Unearned Income
Absolute poverty line $4.30 USD-line (1USD=0.94€)	3255.59	0.20	0.03	0.07	16%	2.7%
Relative poverty line 60% of median	3886.41	0.24	0.04	0.09	16%	3.45%

Source: authors' own calculation

Table 13 shows the distribution of total household income in the sample based on the Gini coefficient. The income distribution was calculated, excluding non-farm incomes too. The Gini coefficient of 0.488 for the farm households in the sample indicates that income distribution is unequal. At the Gini coefficient, which was calculated without considering non-farm incomes, we find a notable increase in the Gini coefficient, namely 0.699; this implies that non-farm income contributes to equal income distribution in rural areas. The examination of partial coefficients calculated based on decomposed Gini coefficients confirms that all household sources reduce inequality, especially the farm income. To calculate Gini coefficients, all households in the sample were considered, including those with no share in the respective income source (MÖLLERS & BUCHENRIEDER, 2011).

Table 13. Income distribution and non-farm incomes

Gini coefficient		
based on adjusted per capita incomes (equivalent scale)	0.488	
non-farm incomes excluded	0.699	
Decomposed Gini coefficients		
-based on farm incomes	0.496	(-0.252)
-based on non-farm incomes	0.754	(-0.0451)
-based on unearned incomes	0.94	(-0.0024)
Gini Total	0.452	

Source: authors' own calculation

5.2 Farmer's Attitude on Using Wheat Straw

According to literature, sale of biomass for briquettes or pellets could be a future option. The price of the new product will primarily determine opportunities.

Table 14. House heating methods.

House heating methods	Mean & S.D.	Number of Animals
Pellets (4.1%)	3.13 ± 0.69 (tons)	
Wood (87.6%)	16.83 ± 8.02 (m^3)	
Wood and coal (7.7%)	10.40 ± 4.08 (m^3)	
	6.07 ± 3.71 (tons)	
Farm size		
Wheat (15.6%)	4.40 ± 9 (ha)	2.07 ± 2.76
Wheat and corn (84.4%)	6.41 ±17.32 (ha)	7.81 ± 14.76
	4.49 ± 9.15 (ha)	

Source: authors' own calculation

The table above (table 14), shows that around 96% of the farmers use wood for heating purposes; 87.6% use only wood, 7.7% use wood associated with coal and 4.01% use pellets. From the total sample, 15.6% of farmers had only wheat with an average number of animals of 2.07, while other farmers who had more animals also had a higher area of corn cultivation, which means they are using corn and wheat in rotation.

5.2.1 Contract Volumes and Price Preferences

Farmers' preferences regarding quantity (Figure 18) and price (Figure 19) of straw sold via contracts with a power plant are as follows: The highest frequency was for supplying a fixed area of straw, for a spot market price, while the second-highest was for supplying an amount dependent on farm surplus. As for price, the second most popular response was a fixed price.

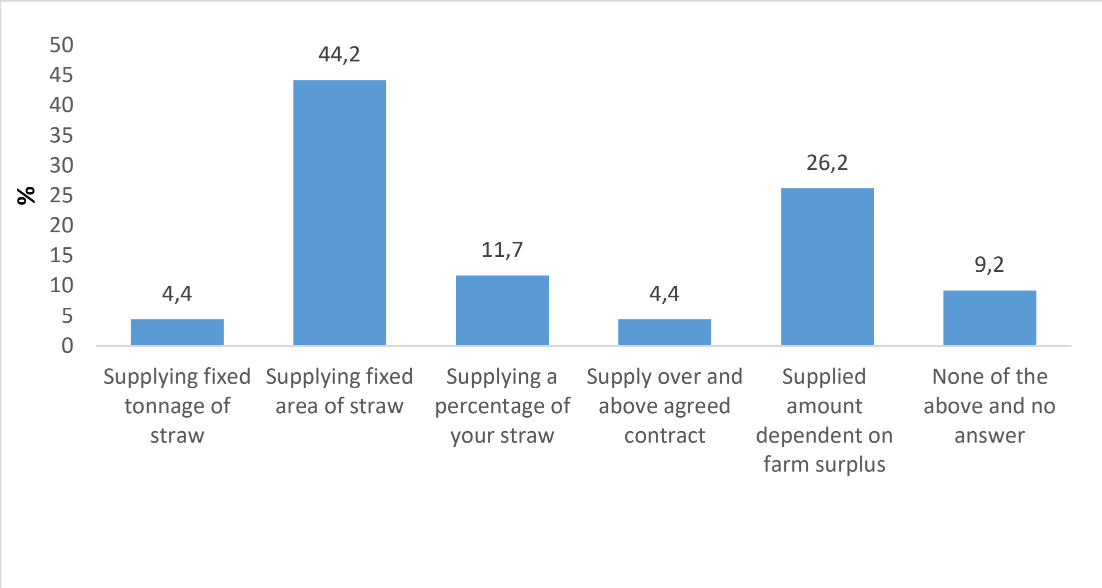


Figure 18. **Quantity supply contract preferences (sample size: 206).**
Source: authors' own calculation

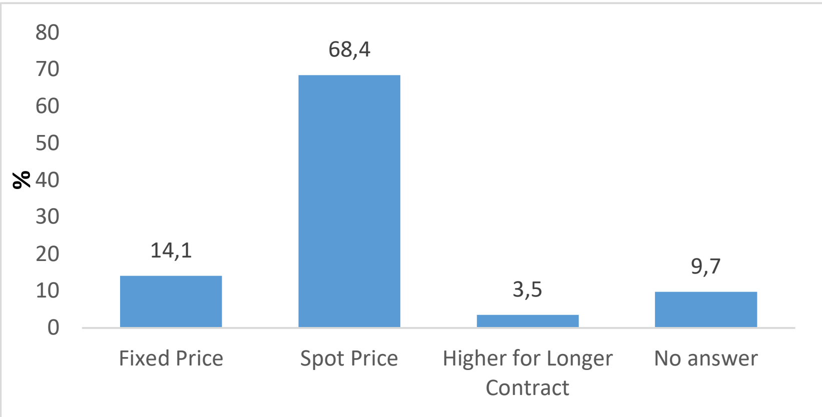


Figure 19. **Price supply contract option preferences (sample size: 206).**
Source: authors' own calculation

Almost half of the farmers are willing to supply a fixed area of straw (44.2%) with a spot market price (68%). Similar results can be found in GLITHERO ET AL. (2013*A*) study, where 42% of farmers chose to supply a fixed area of straw, while the most popular response was fixed price (34% of farmers); this means that farmers do not want the risk of losing potential gains when market prices rise in Kosovo. The potential market of straw for bioenergy purposes is new to most farmers, so it is possible that they can expect the price to rise if this industry starts to take off. According to KUROWSKA ET AL. (2014), an unstable biomass market and its price fluctuations are seen as a weakness and threat, whereby the poor state of infrastructure and an unfavourable fuel situation can harm the market (BRODZIŃSKI ET AL., 2014).

5.2.2 Reasons for not Baling Straw and Incentives to Encourage Baling

In the study done by GLITHERO ET AL. (2013*A*), the lack of a market and machinery were excuses given by less than 10% of the farmers.

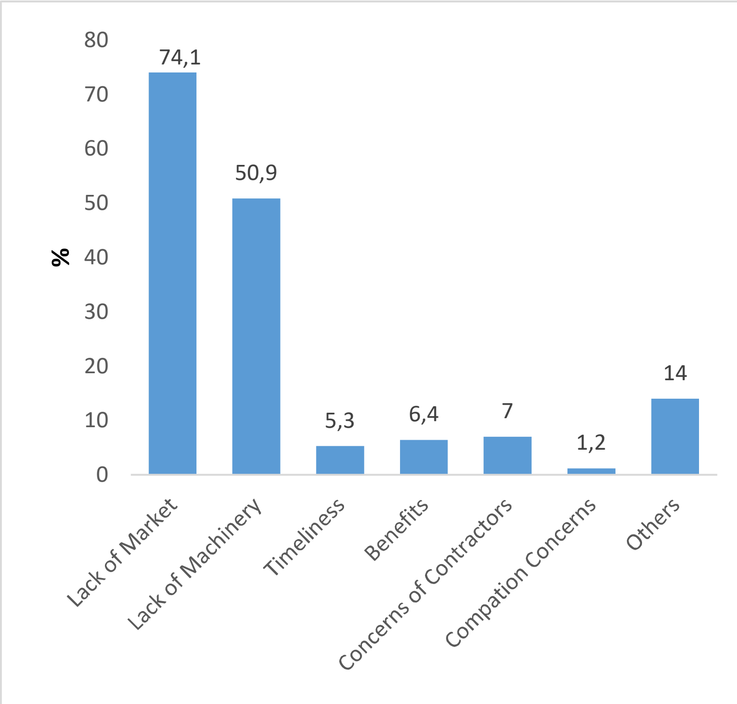


Figure 20. Reasons for not baling/selling straw (sample size: 206).
Source: authors' own calculation

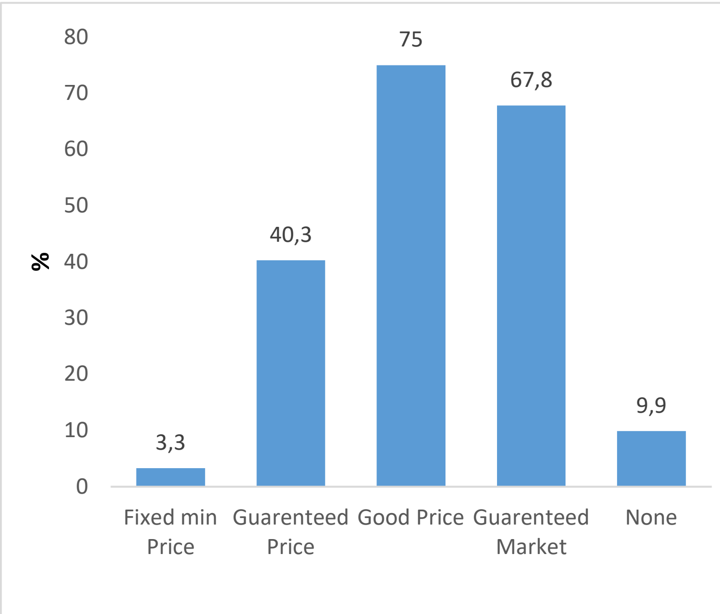


Figure 21. Incentives to encourage straw baling (sample size: 206).
Source: authors' own calculation

When farmers were asked about their reasons for not baling/selling (including selling in swath) some or all of their straw (figure 20), the most popular response was a lack of market interest (74.1%) and the second reason was a lack of machinery (54.9%). These two reasons were also the most popular responses for corn. Additional reasons for not baling were mentioned less often, such as the time of operation (i.e., delays in establishment of the next crop), the perceived benefits of incorporation (soil structure/nutrients), concerns about contracts, and concerns about concerns soil quality. Around 50.9% of farmers sold their straw at the farm gate, and a few farmers did not bale due to timing of operations or incorporation of straw. When farmers were asked about factors that would motivate them to bale and sell their straw (figure 21), the most popular response was a good price (75%), followed by a guaranteed market (67.8%) and guaranteed price (40.3%). Farmers were generally less interested in a fixed price, and some of them will not be encouraged by any of these reasons.

5.2.3 Length of Supply and Contract

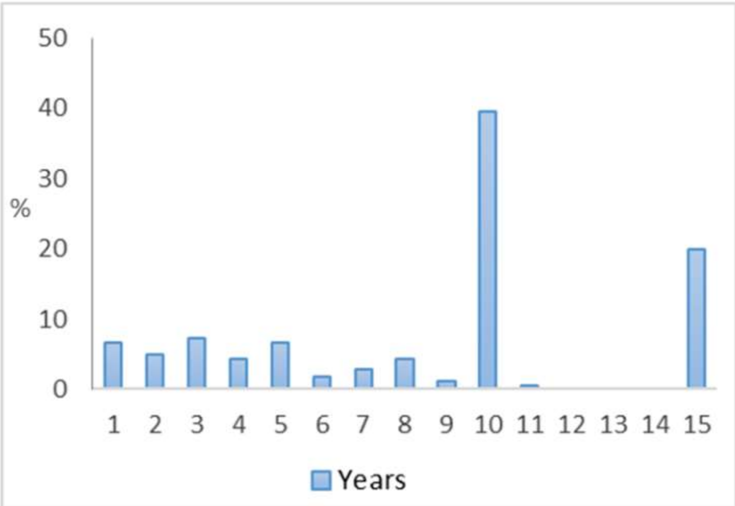


Figure 22. Maximum Contract Length Supplying.
Source: authors' own calculation

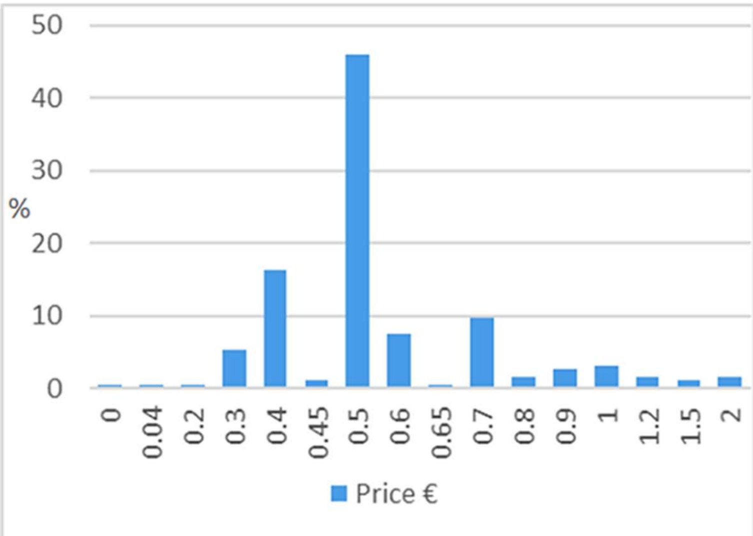


Figure 23. The Preferred Price of Straw (sample size: 206).
Source: authors' own calculation

Farmers were asked about the length of time (in years) (Figure 22) they would prefer to consecutively supply straw to a bioenergy plant and the maximum contract length that would be acceptable to them. Almost all farmers gave the same response for both, so we combined them into one question. The most popular contract lengths were 10 years (39.4%), 15 years (20%), and three years (7.2%). Note that while contract lengths of 15 years or less were most popular, none of the farmers rated 12, 13, or 14 years, while 6.7% of farmers preferred a five-year contract. The minimum price for which farmers were willing to sell straw was €0.50/bale (Figure 23); this was selected by 45.9% of all respondents, with 0.5% of farmers able to give it for free at a farm gate (if harvested by the one who receives it). The highest price was €2/bale; 28% of all respondents already sold straw, and of these 52% sold it for a price of €0.5/bale, which is the market price, while the highest price was €1 (16% of farmers). The other 71.6% did not sell at all. Additionally, one bale was equal to 15 kg straw, and 90.7% of farmers from the sample would be willing to sell their wheat straw to a bioenergy plant, while 9.3% did not agree to sell it; thus, in general, from price per ton would be 38 euros, different studies use different prices per ton, like 56.48 euros/ton, 32 euros/ton, or 50 euros/ton (ELBERSEN ET AL., 2010; GLITHERO, RAMSDEN, ET AL., 2013; MARKS-BIELSKA ET AL., 2019). Similar results can be seen in Poland, where biomass production primarily depends on raw material prices and a guaranteed market (BRODZIŃSKI ET AL., 2014).

5.2.4 Actual Use of Wheat and Corn Straw

During the period 1999-2019, straw consumption (bedding and feed) decreased by approx. 60%. Consumption of straw for fodder after years of decline, since 2002, has remained at a relatively same level. These trends result from a decrease in total livestock population and stabilization of ruminant populations (mainly cattle) since 2002 (GRADZIUK, 2015). Straw is also used in the horticulture sector, mainly for mushroom production, and in minimal quantities in the industrial sector (SPÖTTLE ET AL., 2013). The amount of crop residues used for competitive use varies widely across countries. In particular, Ireland and the Netherlands use a higher share of collectable crop residues for animal bedding (MONFORTI ET AL., 2013). On the other hand, many regions or countries, e.g., the U.S., E.U., China, India, Australia and Southeast Asia, have banned straw burning, although these bans were likely based on a singular view that is still under debate (PANDEY ET AL., 2017; TORE, 2019).

From table 15, we can see that most of straw is used for bedding (37.60%) and feeding animals (19.39%); there is a very low amount of straw that is incorporated back into the soil (9.73%) the other 33.38% is sold, given for free, or burned, while willingness to sell it for energy purposes is around 65%. According to COPERLAND & TURLEY (2008), straw is used to feed livestock, and roughage can compromise a minimum of 10% of the feed ration; however, it is impossible to know the exact quantitie used because different farmers have different feeding systems and straw bedding depends on livestock production, age, and management practices. Furthermore, different studies state that dry straw has no value as an animal feed, although it can be baled, used as bedding, ploughed back into the ground, or burned, causing environmental problems due to gas release into the atmosphere (CASCONE ET AL., 2019; PALMIERI ET AL., 2017). From the results, we can conclude that, in general, farmers are willing to supply more than half of their straw (64.73%); similar results were found in the study by GLITHERO ET AL. (2013*A*). From the total sample, 45% of farmers were willing to sell 33.07% of their straw; these farmers were part of the first group, characterized by the willingness to sell less than 50% of the total straw. The second group was characterized by a willingness to sell more than 50% of the straw; this group contained 55% of the farmers willing to sell an average of 89.73% of straw. In the study of BATIDZIRAI ET AL. (2016), 80%–85% of the biomass was available at the farm gate; however, they required a minimum of 2 t ha^{-1} of residues to reduce soil erosion, and additional analysis would allow for a more accurate evaluation of sustainable residue removal rates. The details of our study are as follows: few farmers incorporate wheat straw into soil, 20 (9.8%) respondents incorporate between 20-50% of straw, while ten farmers or 4.9% of the sample incorporate straw 100% into soil. The other part, 173 (84.8%), do not incorporate straw at all. Only two farmers declared that they burn 100% of straw into the field; the others 99% do not burn it at all. However, this issue needs particular attention because the number of farmers who burn straw is very low in our sample, while in reality, the Ministry of Environment and Spatial Planning calls for farmers not to burn straw as there is a risk of burning buildings or forests. Bedding straw practice was applied by 48.5% of farmers, 33 (16.2%) of respondents use around 50% of straw for bedding purposes, 51 (25%) farmers use 100% of their straw for bedding.

Furthermore, 56 (27.5%) farmers use around 50-100% of their straw for animal feed, while most of them 133 (65.2%) do not use it at all. Some farmers were able to find a market for selling straw; 36 (17.6%) of farmers sell their straw 100%, 15 (7.4%) sell around 50% of their straw, while the other part 146 (71.6%) do not sell it at all. There are 20 farmers who give straw for free in exchange for wheat harvest; 18 (8.7%) of them give 100% of their straw.

Table 15. Straw use practices in a sample size of 206 farmers.

Percentage	Incorporated into soil	Burn into field	Bedding	Feeding	Sell it	Give it for free	Willingness to sell
0	173(84%)	204(99%)	106 (51.5%)	133 (64.6%)	148 (71.8%)	186 (90.3%)	18 (8.7%)
10	1 (0.5)			1 (0.5%)			3 (1.5%)
15					1 (0.5%)		1 (0.5)
20	3 (1.5%)		1 (0.5)	2 (1%)			9 (4.4%)
25	1(0.5%)			1 (0.5%)			
30	1 (0.5)			12 (5.8%)	1 (0.5%)		11(5.3%)
35	1 (0.5)		1 (0.5%)				
40				1 (0.5%)	1 (0.5%)		3(1.5%)
45	1 (0.5)						
50	13 (6.3%)		35 (17%)	39 (18.9%)	15 (7.3%)	1 (0.5%)	48 (23.3%)
55			1 (0.5%)				
60				1 (0.5%)	1 (0.5%)		11 (5.3%)
65			1 (0.5%)				
70	1(0.5%)		9 (4.4%)	1 (0.5%)	1 (0.5%)		5 (2.4%)
75	1 (0.5%)			1 (0.5%)			4 (1.9%)
80				1 (0.5%)	2 (1%)	1 (0.5%)	14 (6.8%)
85				1 (0.5%)			
90			1 (0.5%)				7 (3.4%)
95							
100	10 (4.9%)	2(1%)	51 (24.8%)	12 (5.8%)	36 (17.5%)	18 (8.7)	72 (35%)
Mean(%)	9.73	0.97	37.60	19.39	22.94	9.37	64.73

Source: authors' own calculation

Farmers were asked if they were willing to sell straw for energy purposes; from the total sample, 18 (8.7%) did not accept to sell straw, while the other part, 91.3%, are willing to sell it but in different amounts or percentages. Almost all farmers had a refereeing point of 50% (less or more than 50%).

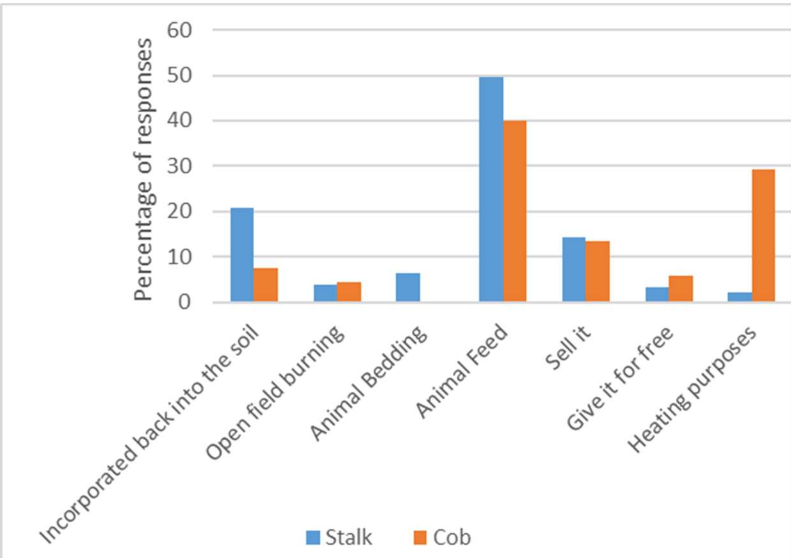


Figure 24. Actual Use of Straws and Cobs (sample size: 206)
Source: authors' own calculation

Because most of the farmers had corn, we asked them about use of corn straw (figure 24). Farmers were allowed to respond with more than one answer. On the actual use of corn straw, the most popular answer was for animal feed, where straws were 49.5% and cobs were 39.9%; this difference could be because some of the farmers used special machinery that grates straws and cobs together and uses the result as animal feed, while farmers who did not use this machinery used only straws as animal feed and other farmers left it on the soil (grated or in its basic form). There are cases where farmers used cobs for heating purposes (29.3%) and gave them away for free. MORISSETTE ET AL. (2013) explained the potential for heat production using baled corn stove as a complementary energy source to wheat straw.

5.2.5 Descriptive Data of Farmers

Concerning the socioeconomic factors of willingness to sell straw, the results (table 16) showed that most of the farms cultivated mixed cultures of wheat and corn; their average land size for wheat was 6.41 ha and for corn it was 4.49 ha, with the average number of animals being 7.81; on the other hand, a low number of farmers cultivated only wheat with an average land size of 4.40 ha and an average number of animals of 2.07. From the total sample, more than a quarter of farmers worked outside agriculture (including those employed in the public sector or private sector, self-employed in the nonagricultural sector, and other), while the others did not have any other work except agriculture. More than three-quarters of farmers had finished secondary school, and the rest had finished university. As for the land area devoted to wheat, most wheat farmers (89.3%) had large-scale farms of 0.01–9.99 ha, while a minority had >10 ha. Almost the same true for corn: the majority of farmers (92.7%) had 0.01–9.99 ha and only a few had >10 ha. When farmers were asked if they incorporate straw into the soil, most (84%) declared that they do not incorporate straw, while the others said the opposite. From the total sample, more than half of farmers (68%) have animals, while the others have none. More than half (69.4%) of the farmers were engaged in agriculture as a full-time occupation, while the others were part-time farmers. As for age, 34% of the farmers were 20–40 years old, while the others were over 40. When asked if they were willing to sell corn straw for energy purposes, 11.6% of the farmers declared that they are not planning to plant corn at all; 36.9% were willing to sell <50% to power plants, and the other parts (51.5%) were willing to sell more than 50%. Around one-quarter of the farmers had more than nine family members, while the rest had households of 1–9 members (the average). Only 45.1% of farmers wanted to sell less than half of their straw, while the rest were willing to sell more than 50% of straw. The average price for farmers who are willing to sell less than 50% was 0.59 (€/15-kg bale), and for those who wanted to sell more than 50% of straw the price was 0.56; however, this is not a significant difference ($p < 0.05$). The average price is 0.57 euro per bale.

Table 16. Farmers' basic characteristics.

Factor	Code and Sort	Frequency	%	Mean and St. dev
I. Farm type	[0]. Wheat	32	15.5%	0.656 ± 483
	[1]. Wheat and Corn	174	84.5%	0.523 ± 500
II. Employment	[0]. Outside of Agriculture	68	33%	0.5882 ± 0.496
	[1]. Agriculture	138	67%	0.5217 ± 501
III. Education	[0]. Elementary/higher school	166	80%	0.5361 ± 500
	[1]. University	40	19%	0.575 ± 500
IV. Soil Concerns	[0]. Not Incorporated	173	84%	0.503 ± 501
	[1]. Incorporated into the soil	33	16%	0.758 ± 0.435
V. Animals	[0]. Do not have animals	66	32%	0.879 ± 0.323
	[1]. Have animals	140	68%	0.386 ± 0.489
VI. Engagement in agriculture	[0]. Part-time farmer	63	30.6%	0.556 ± 0.500
	[1]. Full-time farmer	143	69.4%	0.539 ± 0.500
VII. Currently sell straw	[0]. Do not sell straw	148	71.8%	0.487 ± 0.501
	[1]. Sell straw	58	28.2%	0.690 ± 0.467
VIII. Age	[0]. 20–40 years old	70	34%	0.571 ± 0.498
	[1]. ≥ 41 years old	136	66%	0.529 ± 0.501
IX. Percentage of corn straw	[0]. Not planning to plant corn	24	11.7%	0.67 ± 0.482
	[1]. ≤50%	76	36.9%	0.08 ± 0.360
	[2]. ≥51%	106	51.5%	0.86 ± 0.350
X Land area of wheat	[0]. 0.01–9.99	184	89.3%	0.544 ± 0.500
	[1]. ≥10	22	10.7%	0.546 ± 0.510
XI. Land area of corn	[0]. 0–9.99 ha	191	92.7%	0.55 ± 498
	[1]. ≥10 ha	15	7.3%	0.47 ± 516
XII. Household size	[0]. (1–9)	154	74.8%	0.533 ± 0.500
	[1]. (≥10)	52	25.2%	0.577 ± 0.499
Dependent variable	[0] (≤50%)	93	45.1%	33.07% ± 20.01
(Willingness to sell wheat straw)	[1] (≥51%]	113	54.9%	89.73% ± 16.58

Source: authors' own calculation

5.2.6 Binary Logistic Regression

Binary logistic regression was used to check significant factors influencing the willingness of farmers to sell their straws. The logistic regression model gave a statistically significant result of $\chi2(9) = 131.095$, $p < 0.001$. This model explained between 47.1% (Cox and Snell R^2) and 63% (Nagelkerke R^2) of the variance in the percentage of willingness to sell straw and correctly classified 85.9% of the cases. Additionally, we obtained an insignificant value for the goodness-of-fit test (Hosmer and Lemeshow) $\chi2$ (8) = 9.146, $p > 0.330$. Table 17 presents the logistic regression output of the factors determining farmers' willingness to sell straw in Kosovo.

The results showed that the predicted logit of (PERCENTAGE OF WILLINGNESS TO SELL) = 1.827 + (–1.034) * SELL IT + (0.620) *SOIL CONCERNS + (–3.535) * ANIMALS + (–0.992) *TIME SPENT ON FARM + (–0.463) *AGE OF FARMER + (0.162) * WHEAT AREA + (–3.316) * FARM TYPE + (0.239) * EMPLOYMENT + (0.024) * LEVEL OF EDUCATION + (3.393) * P. CORN STRAW + (–0.165) * CORN AREA + (0.326) * FAMILY.

Binary logistic regression (Table 17) showed that farmers who already sell straw and have animals, farmers who have corn, and the percentage of willingness to sell the corn straw were significant predictors of willingness to sell the wheat straw ($p < 0.05$), while engagement in agriculture can be potentially significant ($p < 0.1$). Soil concerns, corn area, wheat area, farm type, employment, education, and the number of family members were marginally nonsignificant ($p > 0.05$).

5.2.7 The Impact of Socio-Economic Factors on The Willingness to Sell Straw

The results of table 17, shows the impact of socio-economic factors on the willingness to sell the straw, which are described below;

(I) Currently, selling wheat straw has a significantly negative ($p < 0.05$) relationship with the percentage (more than >50%) of willingness to sell straw. Farmers who already are selling straw in the market are willing to sell more than half of it to power plants, while we can see a decrease for the others who do not already have a market, which means that even if they had a market, they would tend to sell less than half of the wheat straw. As a result, there are increases in farms that have a market for selling straw; the odds ratio of percentage of willingness to sell increases by 2.808 (1/0.356) ($\beta = -1.034$) times compared to farmers without a market. The contrasts between market and no market are depicted by the average farmer's willingness to sell more than half of their straw being higher (0.690 ± 0.467) than without a market (0.487 ± 0.501).

(II) As for soil concerns, we can see a positive impact on the willingness to sell straw. Farmers who do not incorporate straw into the ground tend to sell less than half of straw; this could be because they use it for other purposes. Those who incorporate it into the soil are 1.859 (= β 0.620) times more likely to sell more than half of straw if there is a market for straw. This can explain why soil concerns are low and farmers who are not incorporating into the soil are using it for other purposes (feeding animals or selling it). The variation between soil concerns shows that farmers who do not incorporate straw into the soil are less likely to sell more than half of their straw (0.503 ± 0.501) compared to those who incorporate it into the soil (0.758 ± 0.435). this is contrary to the findings of GLITHERO ET AL. (2013*A*), in which almost half of the farmers who currently incorporated their straw were not willing to bale straw for bioenergy purposes.

(III) Moreover, animals have a significantly negative impact on the willingness to sell straw ($p < 0.05$). Farmers who have animals tend to sell less than half of their straw, while those who do not have animals are 34.483 (1/0.029) (= β −3.535) times more likely to sell more than half of their straw. Farmers who do not have animals are highly likely to sell more than half of straw (0.879 ± 0.323), compared to those who have animals (0.386 ± 0.489).

(IV) Engagement in agriculture (part-time or full-time) tends to have a significant impact ($p < 0.1$) on willingness to sell straw. However, part-time farmers are 2.695 (1/0.371) (= β −0.992) more likely to agree to sell more than half of their straw (0.556 ± 0.500), compared with full-time farmers (0.539 ± 0.500).

(V) Age has a negative impact on willingness to sell more than half of straw: farmers aged 20–40 years were willing to sell >50% of straw for around 1.589 (=β −0.463) times more than older farmers; however, this difference was not significant and so is not considered to shape the willingness to sell straw.

(VI) Land area of wheat has a positive impact on the willingness to sell straw: farmers who have less than 10 hectares tend to sell less than half of straw, while those who have more than 10 hectares are 1.175 (= β 0.162) times more likely to sell >50% of straw; however, this is not significant. Farmers who have more than 10 hectares have a higher probability of selling more than half of the straw (0.546 ± 0.510) compared to those who have less than 10 hectares (0.544 ± 0.500); however, this is a slight difference ($p > 0.05$). According to GRADZIUK ET AL. (2020), willingness to sell straw was not related to farm size; however, the economic potential of straw used for energy production depends on the average size of farms. Small farms reduce substantially the possibility of using high-performance, large-sized presses, which in turn determines the economic feasibility of biomass supply.

(VII) Farm type has a significantly ($p < 0.01$) negative impact on willingness to sell more than half of straw; we can see that farmers who have only wheat are willing to sell more than half of their straw, compared with the farmers who have both corn and wheat. Farmers who have only wheat are 27.777 (= β −3.316) times more likely to sell straw than farmers who have both corn and wheat.

(VIII) Employment is also not significant in terms of willingness to sell straw; however, farmers whose primary profession is outside of agriculture tend to sell more than half of straw (1.27 (= β 0.239) times more likely than farmers who deal only with agriculture).

(IX) Education: farmers who are educated to university level tend to sell more than 50% of straw; however, this is not a significant factor shaping willingness.

(X) The willingness of farmers to sell more than half of the corn straw has a significantly positive impact on the willingness to sell the wheat ($p < 0.05$). Farmers who sell less than 50% of corn straw tend to sell less than 50% of wheat straw (0.08 + 0.360). Farmers who sell more than half of the corn straw tend to sell more than half of their wheat straw, too (0.67 + 0.482); they are 29.748 times (β = 3.393) more likely to sell it compared to those who sell less than 50% of corn straw.

(XI) Land area of corn has a negative impact on the willingness to sell straw: farmers who have more than 10 hectares of corn tend to sell less than half of their straw (0.47 ± 0.516), while those who have less than 10 hectares are 1.179 (= β −0.165) times more likely to sell more than half of the wheat straw on average (0.55 ± 0.498); however, this is not significant ($p > 0.05$) and could be because farms with a higher area of corn also have more animals.

(XII) Household size: those farmers with more than 10 family members are more likely to be willing to sell more than half of their straw, compared with the group 2 family size (1–9).

As shown in table 17. except for having a market, having animals, farm type ($p < 0.05$), and engagement in agriculture ($p < 0.08$), all other variables do not have an impact on the willingness to sell the wheat straw. It can be statistically justified ($p < 0.05$) that only three variables included in the model have an impact on the willingness to sell straw. Papers on methodology recommend the use of the so-called R value to express the role and power of specific independent variables in a model. The size of the value denotes the order of "importance" of independent variables. This index is not a part of the model's output; it needs to be calculated using the following equation: $R = \sqrt{\frac{Wald-2df}{Do}}$. Willingness to sell straw is mostly (0.383) shaped by the willingness to sell the corn straw, followed by the presence of animals on the farm (0.306), farm type (0.231), and the partial impact (0.059) of engagement in agriculture and of having a market (0.083).

Table 17. Binary Logistic Regression; Factors Affecting the Percentage of Willingness to Sell Straw.

FACTORS	B	S.E.	Wald	Df	Sig.	Exp(B)	R
Sell straw	-1.034	.521	3.940	1	.047	.356	0.083
Incorporated into soil	.620	.599	1.072	1	.300	1.859	-
Have cows	-3.535	.662	28.479	1	.000	.029	0.306
Fulltime/part-time	-.992	.573	2.999	1	.083	.371	0.059
Age	-.463	.444	1.088	1	.297	.629	-
Wheat size	.162	.830	.038	1	.846	1.175	-
Corn size	-.165	1.048	.025	1	.875	.848	-
Farm Type	-3.316	.801	17.120	1	.000	.036	0.231
Family	.326	.495	.433	1	.511	1.385	-
Employment	.239	.543	.193	1	.660	1.270	-
Education	.024	.592	.002	1	.968	1.024	-
% Willing to sell corn	3.393	.513	43.671	1	.000	29.748	0.383
Constant	1.827	.778	5.522	1	.019	6.217	0.111

-2log likelihood 152.537; Hosmer and Lemeshow ($\chi 2 = 9.146$, df=8, p =0.330); Pseudo R squares (Cox & Snell R Square R2= 47.1%; and Nagelkerke R2= 63%); Overall percentage of correctly predicted= 85.9%; B: unstandardized regression weight; S.E.: standard error; Sig.: significance; Exp(B): exponentiation of the B coefficient; Wald.: Wald chi-square value; Df.: the degrees of freedom ("-") Factors that were not shaped in the percentage of willingness to sell; Soil concerns, age, wheat size, corn size, family, employment, education)

Source: authors' own calculation

5.3 Biomass Assessments

5.3.1 Difference Between Cultivars and Regions for 2019 and 2020 (g, cm/ wheat plant)

Different studies reported differences in wheat due to location, cultivar and year, for example TOWNSEND ET AL. (2017) found small differences on total straw yield between cultivars, and high variability across years, the author suggests that being able to provide accurate straw yield data for cultivars might prove to be difficult. LARSEN ET AL. (2012) also found differences between cultivars ranged 2.7-4.6 tons/ha in two different field experiment similar results we can find also in different studies (DAI ET AL., 2016; R. E. ENGEL ET AL., 2003; GRADZIUK ET AL., 2020).

Table 18. Differences Between Cultivars and Regions for 2019 (g, cm/ plant)

Parameters	Dukagjini Plain	Kosovo Plain	p-value
Height of straw Eu(cm)	72.45[a]±5.51	65.09[a]±5.45	0.000
Height of straw Vu(cm)	75.35[b]±6.79	69.95[b]±5.20	0.000
Height of straw Ex(cm)	65.49[c]±5.13	63.28[c]±4.92	0.003
Average	71.01±7.16	66.18± 5.82	
P-value	<0.05	<0.05	
Spike Eu(cm)	9.55[a]±0.90	10.29[a]±0.71	0.000
Spike Vu(cm)	8.29[b]±1.66	9.01[c]±0.81	0.000
Spike Ex(cm)	8.88[c]±0.88	9.95[b]±0.58	0.000
Average	8.9±1.30	9.75±0.89	
p-value	<0.05	<0.05	
Seeds Eu(g)	2.40[a]±0.60	2.01[a]±0.47	0.000
Seeds Vu(g)	1.85[b]±0.51	2.01[a]±0.46	0.000
Seeds Ex(g)	2.65[c]±0.78	1.91[b]±0.55	0.000
Average	2.30±0.72	1.98±0.49	
p-value	<0.05	<0.05	
Chaff Eu(g)	0.56[a]±0.17	0.68[a]±0.20	0.000
Chaff V(g)	0.45[b]±0.13	0.59[b]±0.13	0.000
Chaff Ex(g)	0.58[a]±0.15	0.64[b]±0.13	0.037
Average	0.53±0.16	0.64±0.16	
p-value	<0.05	<0.05	
Total Straw and leaves Eu(g)	1.56[a]±0.33	1.52[a]±0.30	0.427
Total Straw and leaves Vu(g)	1.27[b]±0.28	1.45[b]±0.27	0.000
Total Straw and leaves Ex(g)	1.43[c]±0.30	1.40[c]±0.29	0.420
Average	1.42±0.32	1.46±0.29	
p-value	<0.05	>0.05	

Stubble (13 cm) Eu(g)	0.30^{a}±0.09	0.32^{a}±0.08	0.101
Stubble (13 cm) Vu(g)	0.27^{ab}±0.07	0.32^{a}±0.09	0.000
Stubble (13cm) Ex(g)	0.34^{ac}±0.07	0.34^{a}±0.10	0.737
Average	0.31±0.08	0.33±0.09	
p-value	<0.05	>0.05	

Note; means sharing common letters do not differ significantly from each other 5% probability level.
Source: authors' own calculation

From table 18. we can see the difference between cultivars and regions during 2019 (the first year of the experiment), according to **the height of straw (cm)**, the three cultivars were significantly different between each other and between regions p<0.05. The highest height of straw had Vulcan in both regions; however, they were significantly different p<0.05 as in the Dukagjini Plain was higher. In the Dukagjini plain, the average height of straw was higher 71.01±7.16, while in the Kosovo plain was 66.18±5.82cm. **The height of spikes (cm)** for the three cultivars were significantly different from each-other p<0.05 and significantly different by region p<0.05. The highest height of spike between the three cultivars had Euclid in both regions. In the Dukagjini plain, the average high of spikes was lower, 8.9±1.30, compared to the Kosovo Plain 9.75±0.89 and p<0.05. **The yields (g)** between the three cultivars were significantly different from each other p<0.05, except Euclid and Vulcan in the Kosovo Plain, which had a similar weight of seeds per wheat plant, while all of them were also significantly different by region p<0.05. The highest yields between the three cultivars in the Dukagjini region had the cultivar Exotic 2.65c±0.78, while in the Kosovo plain, Euclid and Vulcan 2.01a±0.47 with similar weights. In addition, the Dukagjini plain had higher yields (2.30±0.72) than the Kosovo plain (1.98±0.49). **The weight of chaff per plant** is significantly higher in the Kosovo plain 0.64±0.16 compared to the Dukagjini plain 0.53±0.16. The highest weight of chaff had Exotic in the Dukagjini region (0.58±0.15) and Euclid in the Kosovo region (0.68±20). **Straw and leaves/plant -** the highest weight of straw and leaves had the Kosovo plain 1.46±0.29 compared to the Dukagjini Plain 1.42±0.32. There are significant differences between the three cultivars within the region, while there are no significant differences of these cultivars between regions, except the cultivar Vulcan. However, the highest weight in both regions had Euclid.

Stubble (13 cm) in gram- There are significant differences between the three cultivars in the Dukagjini region, while there were no significant differences in the Kosovo plain. The highest weight of 13cm part with straw and leaves had the Kosovo plain 0.33±0.09 compared to the Dukagjini Plain 0.31±0.08. We can say that the Kosovo plain had a higher weight regarding spike, chaff, straw, and leaf, while the Dukagjini plain had a higher weight of seeds and higher cm straw. In the study of ALI ET AL. (2011), maximum plant height (82.35cm) and the minimum was

(69.26cm) depending on the amount of N. The maximum spike length was 10 to 11.30cm. Another study by ALI ET AL. (2000) had the number of tillers from 320 to 380 per m^2, spike length 12.84-17.86cm, grain 3.15-5.44 t/ha and straw yield 5.12-7.57t/ha; in this study, it was not mentioned the cutting point of total dry biomass or collectable straw. According to YOSHIDA (1981), tiller number per plant determines panicle number, a critical grain yield component. The tiller number per unit area is one of the main agronomic components in determining yield (FANG ET AL., 2020).

Table 19. Differences Between Cultivars and Regions for 2020 (g, cm/ plant)

Parameters	Dukagjini Plain	Kosovo Plain	p-value
Height of straw Eu(cm)	68.08^a±5.76	63.68^a±4.82	0.000
Height of straw Vu(cm)	73.45^b±4.90	76.02^b±5.80	0.001
Height of straw Ex(cm)	60.76^c±4.08	61.18^c±5.11	0.533
Average	67.01±7.18	66.98± 8.35	
p-value	<0.05	<0.05	
Spike Eu(cm)	9.31^a±0.82	10.05^a±0.88	0.000
Spike Vu(cm)	8.35^b±0.60	8.57^b±0.73	0.025
Spike Ex(cm)	8.48^b±0.60	10.07^a±0.83	0.001
Average	8.70±0.78	9.56±1.07	
p-value	<0.05	<0.05	
Seeds Eu(g)	1.71^a±0.47	1.93^a±0.50	0.003
Seeds V(g)	1.38^b±0.26	1.35^b±0.35	0.425
Seeds Ex(g)	1.92^c±0.44	1.80^a±0.58	0.146
Average	1.67±0.46	1.69±0.55	
p-value	<0.05	<0.05	
Chaff Eu(g)	0.42^a±0.11	0.43^a±0.15	0.507
Chaff V(g)	0.34^b±0.12	0.32^b±0.14	0.417
Chaff Ex(g)	0.44^a±0.09	0.47^a±0.13	0.069
Average	0.40±0.16	0.41±0.15	
p-value	<0.05	<0.05	
Total Straw and Leaves Eu (g)	1.37^a±0.25	1.48^a±0.31	0.008
Total Straw and Leaves V(g)	1.10^b±0.19	1.36^b±0.26	0.000
Total Straw and Leaves Ex(g)	1.17^b±0.24	1.28^b±0.29	0.005
Average	1.21±0.25	1.37±0.30	
p-value	<0.05	>0.05	
Stubble (13cm) Eu(g)	0.27^a±0.06	0.27^a±0.05	0.919
Stubble (13cm)Vu(g)	0.25^b±0.06	0.29^a±0.07	0.023
Stubble (13cm) Ex(g)	0.28^a±0.06	0.27^a±0.19	0.000
Average	0.26±0.06	0.28±0.12	
p-value	<0.05	>0.05	

Note; means sharing common letters do not differ significantly from each other 5% probability level.

Source: authors' own calculation

According to **the height of straw (cm)** in the second year of the experiment (2020) (table 19), the three cultivars were significantly different between each other and also between regions $p<0.05$, except Exotic cultivar. Again the highest height straw had Vulcan in both regions; however, with significant differences $p<0.05$, contrary to the first experiment where Vulcan had the highest height in the Dukagjini plain, this year its height of straw was the first one in the Kosovo Plain. Similar to the previous year, in the Dukagjini plain, the total average height of straw was higher 67.01±7.18 compared to the Kosovo plain 66.98±8.35cm. **The height of spikes (cm)** in the Dukagjini plain, Euclid had the highest height of spike and was significantly different from Vulcan and Exotic, while in the Kosovo plain, the highest height of spike had Vulcan, and it was not significantly different from Euclid; all of them were significantly different by region $p<0.05$. The highest height of spike between the three cultivars had Euclid in both regions. Again, in the Dukagjini plain, the average height of spikes was lower 8.70±0.78 compared to the Kosovo Plain 9.56±1.07 and $p<0.05$. **The yields (g)** of the three cultivars were significantly different from each-other $p<0.05$, except Euclid and Exotic in the Kosovo Plain. They had a similar amount of seeds per wheat, while regarding the region, contrary to the previous year, cultivars were not significant between each other except the cultivar of Euclid. Like the previous year, the highest yields between three cultivars in the Dukagjini region had the cultivar Exotic 1.92±0.44, while in the Kosovo plain, Euclid 1.93a±0.50, in both regions, the cultivar Vulcan had the lowest yields.

Contrary to the previous year, the Kosovo plain has higher yields (1.69±0.55) than the Dukagjini plain (1.67±0.46), which was significant. **Chaff (g)** is higher in the Kosovo plain 0.41+0.15 than the Dukagjini plain 0.40±0.16; however, this difference is insignificant. The highest weight of chaff had Exotic in the Dukagjini region (0.44±0.09) and Exotic in the Kosovo region (0.47±0.13), while the lowest was Vulcan in both regions. There was no significant difference in cultivars between regions. **Total straw and leaves (g) -** Similar to the previous year**,** the highest weight of straw and leaves had the Kosovo plain 1.37±0.30(g) compared to the Dukagjini Plain 1.21±0.25(g). In both regions, cultivar Euclid had the highest amount compared to Vulcan and Exotic $p<0.05$. There are significant differences between the three cultivars in both regions. **Stubble (13 cm) in (g) -** There are significant differences between cultivars in the Dukagjini region, while there were no significant differences in the Kosovo plain. The highest weight of 13cm stubble had the Kosovo plain 0.28±0.12 compared to the Dukagjini Plain 0.26±0.06. We can say that the Kosovo plain had a higher weight and height regarding spike, seeds, chaff, straw and leaf, while the Dukagjini plain had a higher height of straw in cm.

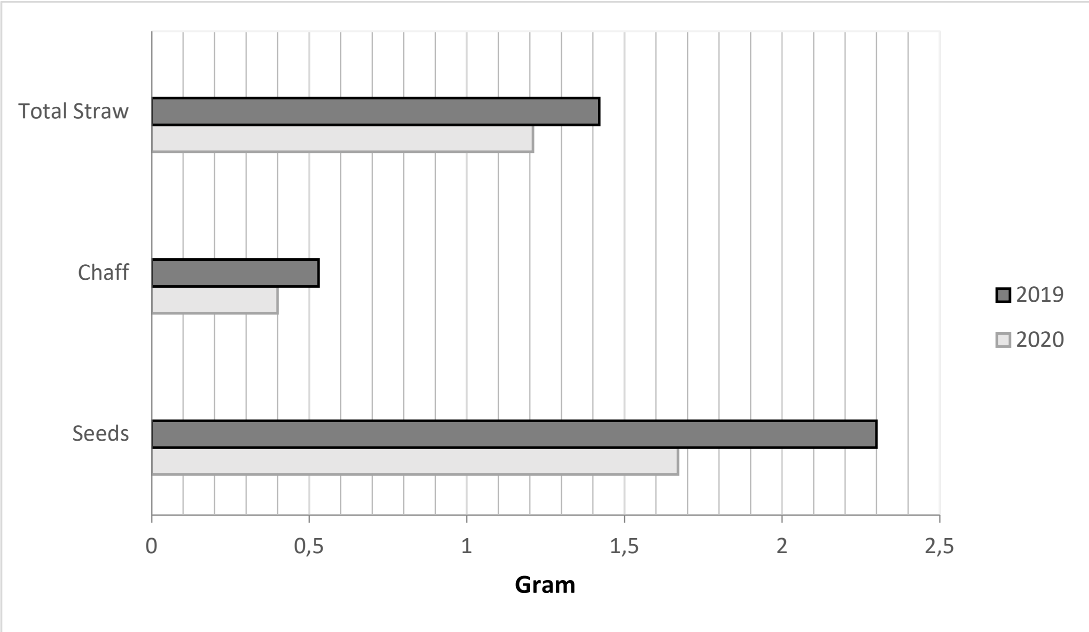


Figure 25 Differences of Wheat Parameters Between Two Years in Dukagjini Plain (g/plant)
Source: authors' own calculation

From figure 25, we can see that in the Dukagjini region, there are also changes between years, the average amount of seed/wheat in 2019 was 37.72% higher than 2020, the same situation stands for chaff, the change between 2019 and 2020 was around 32.5% higher in 2019, the amount of straw between the two years was around 17.35% higher in 2019. As it is seen, the higher change is found on seeds, while the lowest one is on straw. It is worth knowing that straw here is cut around 15cm above ground.

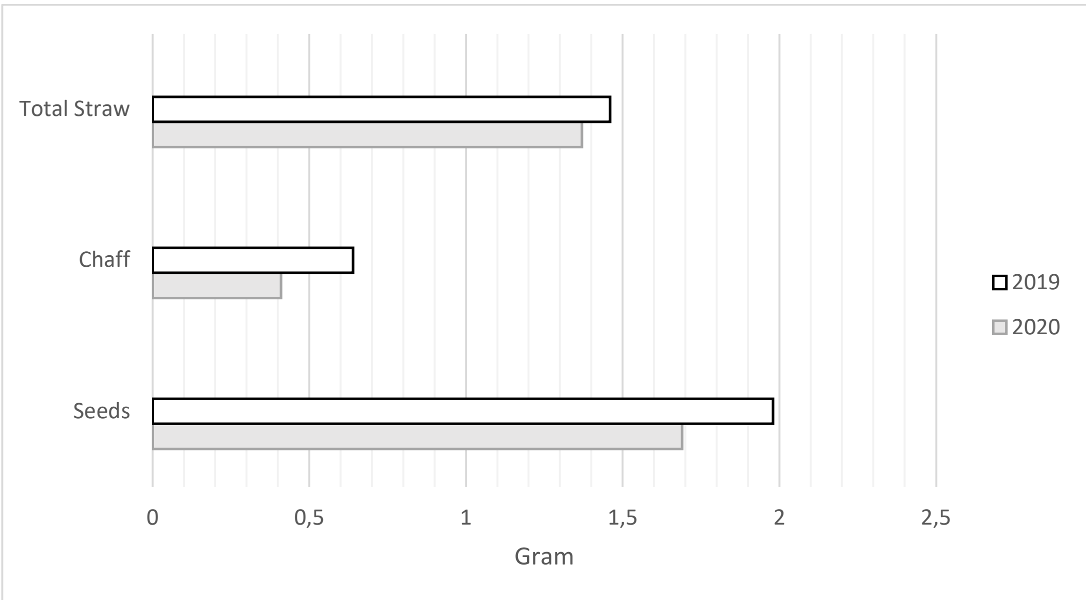


Figure 26. Differences of Wheat Parameters Between Two Years in Kosovo Plain (g/plant)
Source: authors' own calculation

From figure 26, we can see that in the Kosovo Plain, there are also changes between years, the average amount of seed/wheat plant in 2019 was (17.15%) higher compared to 2020, this change is lower if we compare it with the Dukagjini Region, which was 37.72% higher than 2020, the same situation stands for chaff, the change between 2019 and 2020 was around 56.1% higher in 2019, the change is much higher if we compare it with the Dukagjini Region (35.5%), the amount of straw between the two years was around 6.6% higher in 2020. This change is lower if we compare it with the Dukagjini Region 17.35%. As it is seen, the highest change is found on chaff, while the lowest one is on straw. From both figures, we can see that straw was more resistant to natural changes in both regions and between years, its changes fluctuated between 6.6-17.35%. When it comes to seeds, their changes fluctuate from 17.15-37.72%, while the highest change we can find in chaff when from 32.5-56.1%. From this, we can conclude that straw is relatively stable if we use it as feedstock for energy; however, biomass which stays on land, in this case, chaff, can have considerable changes.

5.3.2 Differences Between Cultivars Across the Two Years in Kosovo (gram and cm per wheat plant)

Table 20. Differences of Cultivars Across the Two Years (g, cm/ plant)

Parameters	2019 (a)	2020 (b)	b/a (%)	p-value
Height of straw Eu(cm)	68.76^{a}±6.46	65.89^{a}±5.54		0.000
Height of straw Vu(cm)	72.60^{b}±6.60	74.72^{b}±5.51		0.018
Height of straw Ex(cm)	64.37^{c}±5.13	60.97^{c}±4.61		0.000
Average	68.60±6.96	67.21±7.78	-2.03%	0.002
p-value	<0.05	<0.05		
Spike Eu(cm)	9.93^{a}±0.88	9.68^{a}±0.93		0.008
Spike V(cm)	8.66^{b}±1.34	8.46^{b}±0.68		0.068
Spike EX(cm)	9.42^{c}±0.92	9.27^{c}±1.06		0.138
Average	9.33±1.19	9.13±1.03	-2.14%	0.003
p-value	<0.05	<0.05		
Seeds Eu(g)	2.21^{a}±0.56	1.81^{a}±0.50		0.000
Seeds Vu(g)	1.93^{b}±0.49	1.36^{b}±0.30		0.000
Seeds Ex(g)	2.28^{a}±0.77	1.86^{a}±0.52		0.000
Average	2.14±0.64	1.68±0.50	-21.49%	0.000
p-value	<0.05	<0.05		
Chaff Eu(g)	0.62^{a}±0.19	0.42^{a}±0.13		0.000
Chaff Vu(g)	0.51^{b}±0.33	0.33^{b}±0.13		0.000
Chaff Ex(g)	0.62^{a}±0.15	0.46^{a}±0.11		0.000
Average	0.58±0.17	0.40±0.13	-31.03%	0.000
p-value	<0.05	<0.05		

Total Straw and Leaves Eu(g)	$1.54^{a}\pm0.31$	$1.42^{a}\pm0.28$		0.000
Total Straw and leaves Vu(g)	$1.36^{b}\pm0.29$	$1.23^{b}\pm0.26$		0.000
Total Straw and leaves Ex(g)	$1.41^{b}\pm0.29$	$1.22^{c}\pm0.27$		0.000
Average	1.44 ± 0.30	1.29 ± 0.28	-10.42%	0.000
p-value	<0.05	>0.05		
Stubble (13cm) Eu(g)	$0.32^{a}\pm0.09$	$0.27^{a}\pm0.05$		0.000
Stubble (13cm) Vu(g)	$0.30^{ab}\pm0.08$	$0.27^{a}\pm0.14$		0.017
Stubble (13cm) Ex(g)	$0.34^{ac}\pm0.09$	$0.28^{a}\pm0.06$		0.000
Average	0.32 ± 0.09	0.27 ± 0.10	-15.63%	0.000
p-value	<0.05	>0.05		

Note; means sharing common letters do not differ significantly from each other 5% probability level.

Source: authors' own calculation

Table 20 represents the difference between cultivars across two years in Kosovo, and the description of parameters is as follows; according to **the height of straw (cm**), the three cultivars were significantly different from each other and between years p<0.05, in 2020 the height was reduced by 2.03% compared to 2019. **The height of spikes (cm**) was significantly different between cultivars in both years; the highest spike had Euclid in both years; in 2020 the height was reduced by 2.14% compared to 2019. The cultivars where significance did not exist between two years were Exotic and Vulcan. **The yields (g)** three cultivars were significantly different regarding years p<0.05. In 2019 the average of seeds per wheat was 2.14g, while in 2020 was 1.68g, with a difference in percentage around 21.49% p<0.05. There was no significant difference between Euclid and Exotic within the year, while Vulcan was significantly lower within regions. **Chaff (g)** is higher in 2019 with an average of 0.58g compared to 2020 with an average of 0.40g; the difference in percentage was 31.03%, and it was significant p<0.05. The highest amount in 2019 was produced by cultivar Euclid while in 2020 was produced by both Exotic and Euclid with no significant difference. **Straw and leaves (g)/wheat plant -** is higher in 2019 with an average of 1.44g compared to 2020 with an average of 1.29g; the difference in percentage was 10.42%, and it was significant p<0.05. Cultivar Euclid produced the highest amount in 2019 and 2020 with a significant difference (p<0.05) compared to other cultivars. In contrast, the lowest amount was produced by Vulcan in both years. **Stubble (g)/wheat plant -** is higher in 2019 with an average of 0.32 g/wheat compared to 2020 with an average of 0.27g/wheat; the difference in percentage was 15.63%, and it was significant p<0.05. In 2019, we can say that all the parameters (height of straw, spike, amount of seeds, chaff and straw) were higher. The biggest difference was reported on chaff 31.03% and seeds 21.49%.

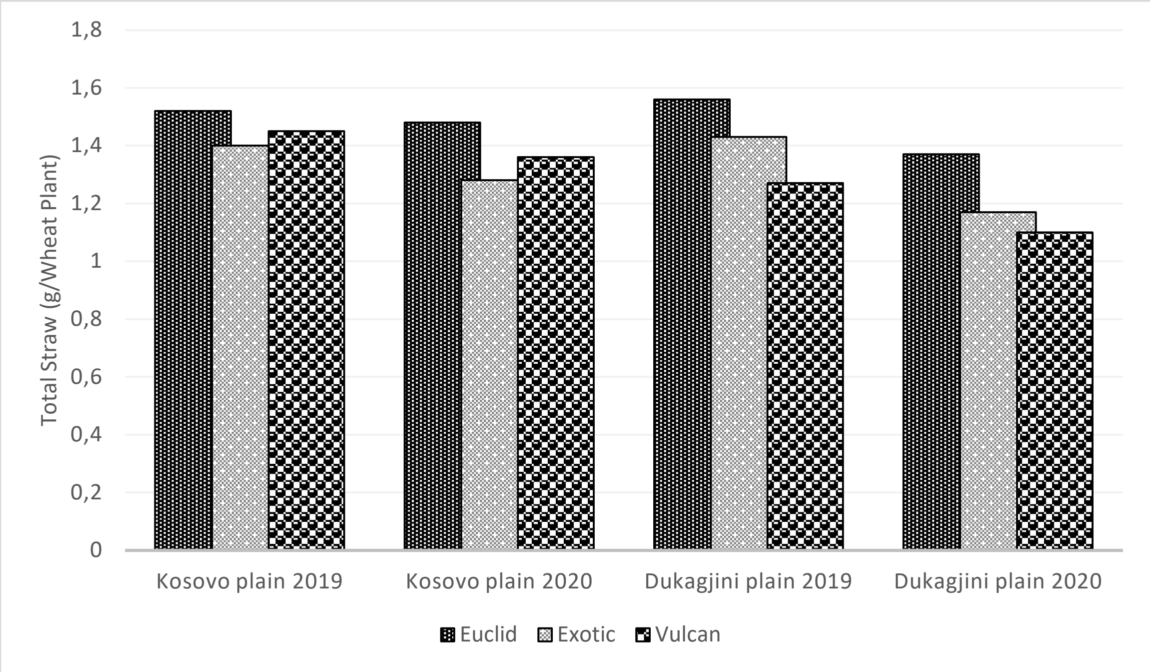


Figure 27. Total Straw Based on Cultivar, Region and Year (g/plant)
Source: Author's own calculation

Figure 27. Represents the results of each experiment in two regions regarding total straw. Three cultivars are measured in gram/plant. From the figure, it is seen that Euclid cultivar has the highest weight of straw per wheat plant compared to other cultivars, in both regions and during two years of experiment, while the situation is different when it comes to Exotic, this cultivar has a higher weight of straw/plant in the Dukagjini region compare to Vulcan. While on the Kosovo Plain cultivar, Vulcan stays better than Exotic.

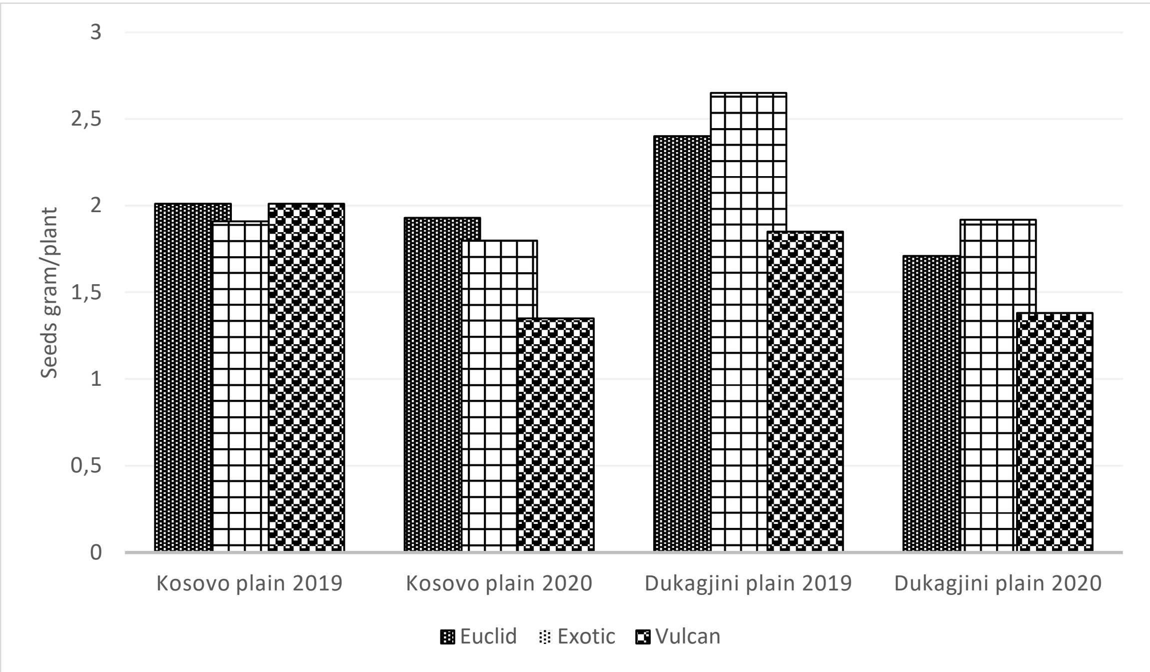


Figure 28. Wheat Yields Based on Cultivar, Region and Year (g/plant)
Source: Author's own calculation

Figure 28. Represents the results of each experiment in two regions regarding the weight of seeds/plant of three cultivars. As it is shown, in the region of the Kosovo Plain, there is no clear distinction as to which cultivar is more suitable/better; however, in the first year, Euclid cultivar is equal to Vulcan, while in the second year, Euclid is the first while Vulcan was the third one. When it comes to the Dukagjini Plan, the distinction is more clear, and the best cultivar is Exotic, the second is Euclid and the last one Vulcan; this position has not changed for two years of the experiment.

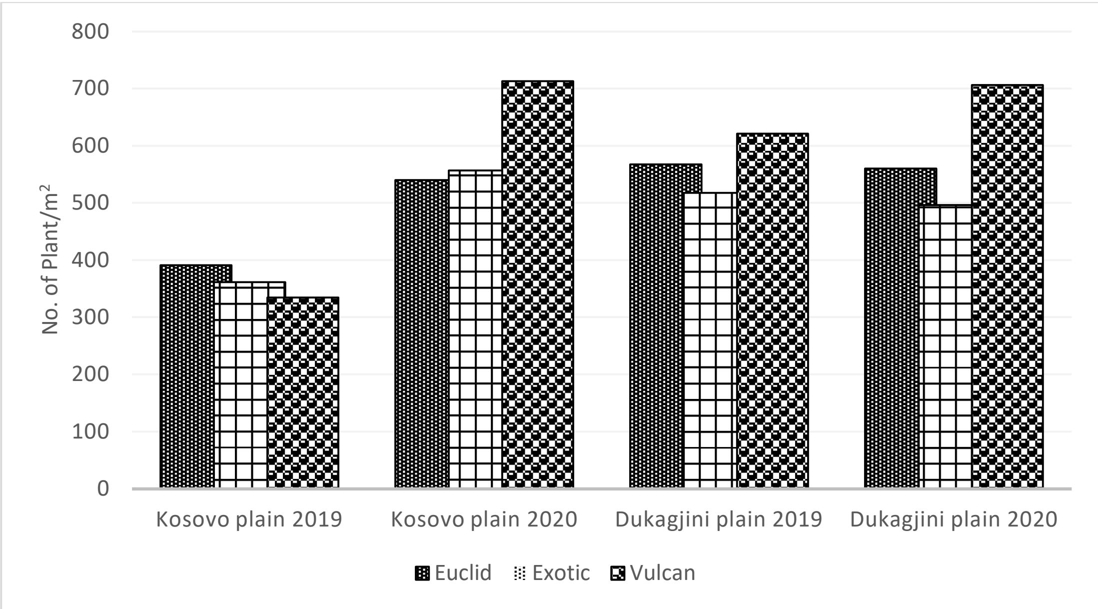


Figure 29. Steam Density Based on Cultivar, Region and Year (plant/m^2)
Source: Author's own calculation

Figure 29 represents the number of plants/m2; we can see that cultivar Vulcan is the best cultivar in the Kosovo plain during 2020 as well as in the Dukagjini Plain this cultivar stays the first one in both years. In the Kosovo Plain 2019 experiment, Vulcan is the third one. If we compare this figure with figure 29, we can conclude that Vulcan has a lower weight of seeds/plant and higher number of plant/m2 compared to other cultivars; similar results are reported in different studies where high plant densities could decrease grain number per spike and 1000-grain weight, and thus could decrease the grain yield per spike and per area (GAJU ET AL., 2014; RAM ET AL., 2013). However, in CAO ET AL. (2019) study, correlations with grain number per spike and 1000-grain weight were not significant; the only key factor that determined grain yield was the number of spikes per hectare, which was significantly positive. According to different authors (BASTOS ET AL., 2020; FANG ET AL., 2020; JIN ET AL., 2016; YOSHIDA, 1981), a high number of wheat plants (plant density) is a critical component in increasing the amount of yield. Thus, the number of plants per m2 can significantly change straw and grain yield of current cultivars; details are given in the table below, where we converted grams to kg per ha. In the study of LIU ET AL.

(2018), we can find 3×106 plants/ha; in the study of CAO ET AL. (2019), this amount varies between 3.67 to 8.33x 10^6/ha spikes while ALI ET AL. (2000) represent the number of tillers 320-380 per m2 with grain 3.15-5.44 t/ha. Different authors' results have shown a high amount of wheat yield; their values are within the range 4430–17 400 kg ha–1 found by previous STUDIES (AHDB, 2017; ASSENG ET AL., 2020; CAO ET AL., 2019; CHEN ET AL., 2011; K. LI ET AL., 2014; C. LU & FAN, 2013; PANDAY ET AL., 2020; SUARDI ET AL., 2020; L. WANG ET AL., 2018; WU ET AL., 2006). In the study KONVALINA ET AL. (2014) we can find 3.13-4.75 ton/ha straw, 1.64-3.47 ton/ha grain, 350 seed m2 (it is not specified if it is total dry biomass or only straw). Table 21 shows the results of three different winter wheat parameters in two regions.

Table 21. Winter Wheat Parameters (Gram/plant and Kilogram/ha)

Region	Type of cultivar	Seeds (gram)	Chaff (gram)	Collectable straw	Stubble (part 13 cm)	Wheat plant m^2	Wheat plant (ha)	Seeds kg/ha	Chaff kg/ha	Collectable straw kg/ha	Stubble (13cm kg/ha
Kosovo Plain 2019	Euclid	2.01	0.68	1.2	0.32	393.09	3930900	7961.18	2693.24	4711.27	1285.09
	Vulcan	2.01	0.59	1.13	0.32	334.33	3343300	6724.17	1957.63	3750.77	1083.43
	Exotic	1.91	0.64	1.06	0.34	361	3610000	6887.77	2318.77	3818.17	1225.73
Kosovo Plain 2020	Euclid	1.93	0.43	1.21	0.27	540	5400000	10396.8	2326.4	6537.03	1446.3
	Vulcan	1.35	0.32	1.07	0.29	713	7130000	9598.6	2314.4	7599.3	2084.6
	Exotic	1.8	0.47	1.01	0.27	557.15	5571500	10053.3	2632.5	5625.63	1503.7
Dukagjini Plain 2019	Euclid	2.4	0.56	1.26	0.3	567	5670000	13616.15	3194	7091.38	1721.17
	Vulcan	1.85	0.45	1	0.27	621	6210000	11506.94	2729.79	6235.43	1671.5
	Exotic	2.65	0.58	1.09	0.34	517.65	5176500	13748.03	3098.02	5625.93	1777.51
Dukagjini Plain 2020	Euclid	1.71	0.42	1.1	0.27	559.89	5598900	9557.9	2340.84	6160.11	1495.15
	Vulcan	1.38	0.34	0.85	0.25	706.43	7064300	9767.8	2407.7	6021.87	1727.94
	Exotic	1.92	0.44	0.89	0.28	496.33	4963300	9506.84	2194.4	4399.01	1403.98

5.3.3 Correlation Between Wheat Parameters

In the study of GLITHERO ET AL. (2013B), there was no clear relationship between harvested grain to straw yields for wheat because the correlation was weak and insignificant (GLITHERO, WILSON, ET AL., 2013), similar results are found in the study of LEE & GROVE (2005) where it is stated that higher grain yields do not always translate into higher straw yields. According to TOWNSEND ET AL. (2017), straw yields were unrelated to grain yields suggesting that cultivars can be selected for high straw yields from among cultivars with high grain yield. According to SCARLAT ET AL. (2010) variation in grain to straw yields observed for three crops (wheat, barley and oilseed rape) is greater than it would be expected from previous estimates of residue to grain ratios. PANDAY ET AL. (2020) found a moderate (R^2 of 0.66) relationship between AGB and plant height. The relationship between crop yield and plant height was stronger (with R^2 of 0.73 and 0.70), respectively, for the spike and grain weights. Similar R2 values (0.74) have been reported for biomass from BATISTOTI ET AL. (2019), who predicted the amount of biomass by estimating canopy height using UAV ROTH & STREIT (2018) calculated AGB based on canopy cover (CC), plant height (PH) and vegetation indices (VIs). He found a significant positive relationship between plant height and biomass. The authors claim that expanding the knowledge of the relationships among PH, VIs and biomass will presumably lead to speedy progress in precision agriculture. In general, there is a strong correlation between straw yield and plant height (R. E. ENGEL ET AL., 2003; LARSEN ET AL., 2012; LONG & MCCALLUM, 2013). The relationship between plant height and straw offers an opportunity to predict straw yield from plant height. Several studies have calculated a relationship between straw yield and straw height. LONG & MCCALLUM (2013) found a strong linear relationship between straw yield and plant height; in their study, crop height was better correlated with straw yield than grain yield or grain protein concentration. ENGEL ET AL. (2005) found straw yield based on straw height, grain yield and soil N availability. Their findings demonstrate that, even though there is a positive relationship between height and yield, it is highly variable, and their finding is valid only for cultivars measured in those studies and cannot be used more widely. However, some authors disagree with the strong relationship between straw yield and height; for example, DONALDSON ET AL. (2001) found that straw yields of a semi-dwarf cultivar did not differ significantly from standard height or tall cultivars, and it may be possible to increase straw yield without increasing height. Many farmers use shorter cultivars and choose management practices to escape straw lodging from weather; however, BRAGG ET AL. (1984) found that although reduced plant height, it did not significantly influence straw or grain yields.

Table 22. Correlation Between Wheat Parameters for 2019 and 2020

The grey areas show the correlation for the first year of the experiment, the white area for the second year of the experiment

Variables	1	2	3	4	5	6
1) Seed(g)	1	586**	.448**	.289**	.053*	.106**
2) Total Straw(g)	.603**	1	-.320**	527**	.142**	.239**
3) Chaff (g)	.622**	.466**	1	.659**	-.320**	-.217**
4) Spike(cm)	.543**	570**	.527**	1	-.299**	-.137**
5) Total Straw(cm)	-.113**	.260**	-.177**	-.253**	1	.986**
6) Plant height (cm)	.042	.345**	-.110**	-.123**	.254**	1

Source: authors' own calculation

Table 22 shows the correlation between wheat parameters of the first (2019) and second (2020) experiment. Regarding the experiment in 2019, we can figure out a significant negative correlation between the height of the straw and the spike $p<0.01$, which means that if straw is higher, spike will be shorter and the opposite. Furthermore, the height of straw has a very low correlation with seed, however it was significant $p<0.05$. Chaff has a significant negative correlation with the height of straw, which means higher straw will produce less chaff, and the last one height of straw has a significant positive correlation with the amount of straw, which means that higher straw will produce more straw (g). The height of the spike has a significant positive correlation with seed $p<0.05$, which means if spike is higher, more seed will be produced. The spike's height also has a significant positive correlation with the amount of chaff and straw, which means if spike is higher, it will produce more chaff and straw. Seeds have a significant positive correlation with chaff and straw $p<0.05$ and no significant correlation with the height of the straw. Chaff also has a strong correlation $p<0.05$ with straw. We suggest that straw is the best predictor for wheat yields.

Regarding the experiment on the second year, from the table, we can figure out that there is a significant negative correlation between height of straw and height of spike $p<0.01$, which means that if straw is taller, spike will be shorter and the opposite, this correlation was slightly higher in 2019. Furthermore, the height of straw had a negative significant correlation $p<0.05$ with seed (R^2 =0.113); however, the correlation was not very strong, this result was quite different if we compare it with the previous year 2019 where there was no significant correlation between height of straw and amount of seed. Chaff has a negative significant correlation $p<0.01$ with the height of straw, which means the higher height of straw will produce less chaff, if we compare it with the previous year, the correlation is weaker this year. The height of straw has a significant positive correlation with the amount of straw, which means that a higher height of straw will produce more straw, and this year the correlation is higher R^2= 0.260 compared to the previous one 0.142; however, both were significant. The height spike has a significant positive correlation (r=0.543) with seed $p<0.05$, if the spike is higher, more seed will be produced, this year, the correlation was stronger compared to the previous one (R^2=0.289). Height of the spike also has a positive significant correlation p<0.01 with the amount of chaff (R^2=0.527) and straw (R^2=0.580), which means if spike is higher, it will produce more chaff and straw. Last year, the correlation between chaff and spike height was stronger (R^2=0.659), while straw was slightly lower (R^2=0.527). Seeds have a positive and significant correlation with chaff R^2=0.622 and straw R^2=0.603, while last year this correlation was weaker (R^2=0.448, p<0.01) with chaff and straw (r=0.586, p<0.01), from the above parameters, it was found that seed had the strongest correlation with chaff (R^2=0.622), last year the strongest correlation was found between seed and straw (r= 0.586). Regarding variables with weak correlations, were found between seed and height of straw (R^2= -113, p>0.01); however, it was significant, the weakest correlation between these two variables was found in last year too (R^2=0.53, p<0.05). The last variable to compare is chaff, which also had a strong correlation p<0.05 with straw (R^2=0.466, p<0.05), last year, this correlation was stronger (R^2=647, p<0.01). It is also worth mentioning that the strongest correlation between all of the variables in 2019 was found between the height of spike and chaff (R^2=0.659, p<0.05), while in 2020, the strongest correlation was found between seed and chaff (R^2= 0.622, p<0.01). Thus we need to merge all variables for both years and decide which variable can better predict the amount of seed; however, there are no technologies that can measure chaff to predict seed, so the weight of seeds can be seen as the best predictor of straw.

Table 23. Correlations Between Wheat Parameters

Variables	1	2	3	4	5	6	7
1) Total Straw (cm)	1						
2) Spike (cm)	-.270**	1					
3) Seed (g)	.030	.367**	1				
4) Chaff (g)	-.182**	.575**	.578**	1			
5) Total Straw (g)	.205**	.543**	.620**	.616**	1		
6) Height of Plant (cm)	.988**	-.121**	-.089**	-.097**	.297**	1	
7) Total Dry Biomass(g)	066*	.607**	654**	.825**	.947**	.164**	1

**. Correlation is significant at the 0.01 level (2-tailed).
Source: authors' own calculation

From the table 23 represents the total number of samples for two years and two regions, seed has a significant positive correlation with straw (g) (R^2=0.620), chaff (R^2=0.578) and spike (cm) (R^2=0.367) p<0.05 and total dry biomass ((R^2=0.654), from the above parameters seed, has the strongest correlation with total dry biomass and total straw and the lowest no significant correlation with the height of straw and plant. Except for seed, straw also has a significant positive correlation with chaff (R^2=0.616), the height of straw (R^2=0.205) and height spike (r=0.543). Straw has a significant positive correlation with all variables, and the strongest one is with seed and total dry biomass. **Chaff** has a positive and significant correlation with seed, total straw, total dry biomass and spike (R^2=0.55) and a significant negative correlation with the height of straw and plant, which means that if a wheat plant has a higher height, it will produce less chaff. **Height of straw** has a significant positive correlation with the amount of straw (R^2=0.297), which means that a higher height of straw will produce more straw and negative correlation with chaff (R^2=-0.097) and height of spike (R^2=- 0.121). **Spike** is significantly correlated with all of the variables seed (R^2=0.367), chaff (R^2=0.575), straw (R^2=0.543) and height of straw (R^2= -0.121), while a strong correlation was found between spike and total dry biomass (R^2= .607). We suggest that in practice seed and height of spike are the best predictor for straw and total dry biomass. Regarding plant height, we can say that the highest correlation is found with the amount of straw; the correlation is significant but not very strong (R^2=0.297) and total dry biomass (R^2=0.164), (notice: straw is harvested 2cm above the ground); we can also find that plant height is positively correlated with seed (in gram) with a significance p<0.01, while negatively correlated with chaff and spike however all these correlations are not strong and vary between R^2=0.08-0.1.

Table 24. Differences Between Cultivars and Regions (kg/ha)

Parameters	Dukagjini Plain 2019&20 (a)	Kosovo Plain 2019&20 (b)	b/a (%)	p-value
Seeds Eu	11554.12^{a}±3637.86	9159.64^{a}±2691.7		0.000
Seeds Vu	10632.72^{b}±2755.1	8138.59^{b}±2501.03		0.000
Seeds Ex	11604.63^{a}±0.77	8453.51^{ab}±3130.6		0.000
Average	11262.17±3464.93	8584.61±2803	-23.8%	0.000
p-value	<0.05	<0.05		
Chaff Eu	2760.52^{a}±900	2512.74^{a}±852.6		0.007
Chaff Vu	2567.87^{a}±847.67	2133.03^{b}±807.1		0.000
Chaff Ex	2641.35^{a}±782.94	2474.9^{a}±638.1		0.025
Average	2656.23±847	2373±789.9	-10.7%	0.000
p-value	<0.05	<0.05		
Collectable Straw Eu	6618.2^{a}±1435	5690.66^{a}±1533.4		0.000
Collectable Straw Vu	6128.08^{b}±1327.3	5644.51^{a}±2523.8		0.021
Collectable Straw Ex	5005.1^{c}±1313.9	4712.18^{b}±1440.9		0.041
Average	5916.5±1515.7	5325.36±1944.2	-10%	0.000
p-value	<0.05	>0.05		
Stubble (13cm) Eu	1606.33^{a}±428	1364.42^{a}±330.1		0.000
Stubble (13cm) Vu	1699.85^{a}±397.2	1576.05^{b}±1105.8		0.150
Stubble (13cm) Ex	1588.74^{a}±381	1363.21^{a}±417.4		0.000
Average	1631.8±404.7	1434.94±715.52	-12.1%	0.000
p-value	<0.05	>0.05		

Note; means sharing common letters do not differ significantly from each other 5% probability level.

Source: authors' own calculation

The table 24 shows that a higher amount of total biomass was produced in the Dukagjini region during the two-year experiment. All three cultivars with their physical parameters in the Dukagjini Plain differed significantly from the Kosovo Plain, except stubble in cultivar Vulcan. On average, compared to the Dukagjini Plain, in the Kosovo Plain, all of the parameters showed lower yield, production of seeds was 23.8% lower, chaff 10.7%, straw and leaves for 10%, and stubble was 12%. From all this, we can see that the highest variability between regions has occurred in seed 23.8%, while the lowest difference was in straw 10%. Regarding seed, Euclid was shown as the best cultivar with a higher amount of seed; however, this was not significant with Exotic cultivar, while Vulcan was significantly lower than Euclid and Exotic.

Regarding chaff, Euclid had the highest amount of it, compared with the other two cultivars; this was insignificant, except in the Kosovo region, where Vulcan was significantly lower than both cultivars. Regarding straw, again Euclid was shown the best cultivar compared to Vulcan and Exotic, in the Dukagjini plain this difference was significantly higher compared with the other two cultivars, while in the Kosovo plain, even though Euclid produced the highest amount of straw, it was insignificant with Vulcan, in contrast, with Exotic cultivar we can find significant changes. Regarding stubble, there are no significant differences within the Dukagjini region while in the Kosovo Plain, cultivar Vulcan is significantly lower than the other two. These are the results collected during the two year experiment; however, yields can change every year; thus, we need to consider changes in each year and region. Vulcan had the lowest amount of seed in both regions; however, it can produce a significantly higher amount of dry biomass than Exotic.

5.3.4 The Share of Total Dry Biomass for the Two Regions

It is suggested that under standard conditions, only about 50% of the non-grain biomass can be baled (steam 5.7t/ha, leaves and dead shoots 2.1 t/ha, chaff 2.1ton/ha and 9.4t/ha grain), even when the height of the combine cut is low (AHDB, 2017). This happens because some residues are unable to collect, like chaff, leaves and stubble. According to BOYDEN (2001), some straw will be left on the field as stubble whilst other parts of straw, particularly leaf and chaff (i.e. the non-grain biomass from the ear), will be lost during combine harvesting and baling. In the study of PANDAY ET AL. (2020), the predicted spike and grain weights were 6.54 tons/ha and 4.53 tons/ha, respectively. Estimation of AGB (ton/ha) in wheat was also made manually on the field (leaves, stems and panicles); around 3.86-15.88 ton/ha was calculated; however, their weight was expressed all together in tons and not separately. In the study of CHERUBINI & ULGIATI (2010), whose straw yield of 6.94 t ha-1 for Austria, it is not specified if residue, chaff and stubbles are left on the field after harvest (i.e. stubble and chaff) or if they are counted together with straw.

GIUNTOLI ET AL. (2013) conducted an LCA for straw for bioenergy for several countries; for the UK, straw production was assumed to be 6.31 t/ha based on the assumption of a 1:0.8 ratio between grain and straw; however, it appears that the whole amount of straw is assumed to be used for bioenergy, as there are no other uses or it is not specified. WANG ET AL. (2013) used a straw yield of 3.2 t ha-1, while NEWMAN (2003) used 5t/ha; these results 3.2t/ha and 5t/ha are supported by TOWNSEND ET AL. (2017) related to the UK average.

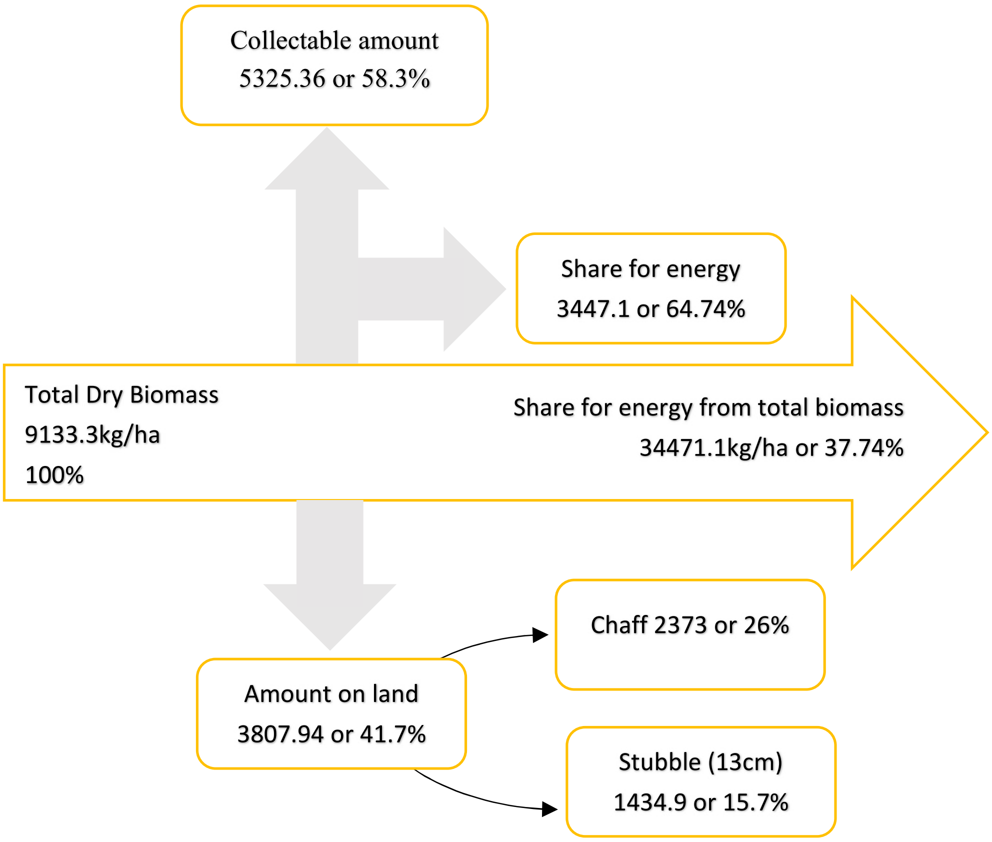


Figure 30. The Share of Total Dry Biomass (on Land, Collectable, Energy Purposes) in Kosovo Plain kg/ha

Source: authors' own calculation

Based on figure 30, in the Kosovo plain, production of total average dry biomass is around 9133.3 kg per ha, from the total dry biomass, only 5325.36 kg/ha or 58.3% is collectable while chaff (2373.23kg/ha) or 26% and the amount of part 13cm (1434.9 kg/ha) 15.7% will stay on land, in total this amount which remains on land (chaff + the part of 13 cm) is around 3807.94 kg/ha or 41.7%, without counting 2 cm of straw above ground which is unmeasured together with roots. If we consider the willingness of farmers to sell straw, which is 64.73%, then, from the total amount of collectable straw 5325.36 kg/ha, only 3447.1 kg/ha would be available to sell for energy purposes. From this, we can conclude that from the total dry biomass 9133.3 kg/ha (chaff, straw,

straw 13cm), based on farmers' willingness to sell straw, only around 37.74% can be used for energy purposes.

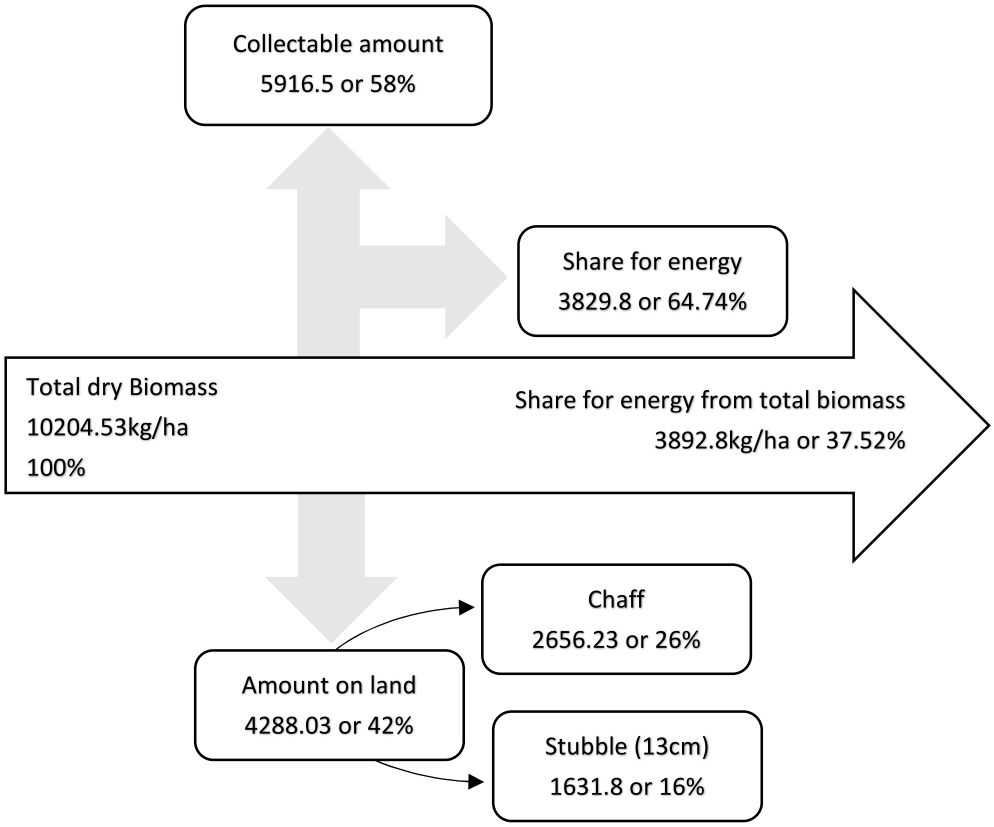


Figure 31. The Share of Total Dry Biomass (on Land, Collectable, Energy Purposes) in Dukagjini Plain kg/ha

Source: authors' own calculation

Based on figure 31, In the Dukagjini plain, the production of total average dry biomass is around 10204.53 kg per ha, from the total dry biomass, only 5916.5/ha or 58% is collectable while chaff (2656.23kg/ha) or 26% and the amount of 13cm (1631.8kg/ha) 16% will stay on land, in total this amount which stays on land (chaff + the part of 13 cm) is around 4288.03kg/ha or 42%, without counting 2 cm of straw above ground which is unmeasured together with roots. If we consider the willingness of farmers to sell straw, this is 64.73%, then, from the total amount of collectable straw 5916.5kg/ha, only 3829.8kg/ha would be available to sell for energy purposes. From this, we can conclude that from the total dry biomass 10204.53 kg/ha (chaff, straw, straw 13cm), based on farmers' willingness to sell straw, only around 37.52% can be used for energy purposes. However, different studies suggest that commercial developers and policymakers could expect modest supply responses for each dollar increase in price (ALTMAN ET AL., 2015; ALTMAN & SANDERS, 2012); however, we did not measure the possible increased amount per dollar.

From the figure above 29 and 30, we can see that the collectable amount of straw is around 58%, our result match with different studies. The available straw for energy purposes from the collectable amount of straw, based on the willingness of farmers to sell straw, is 64.74% we can find a similar result in the study of GLITHERO ET AL. (2013*A*) in England farmers were willing to sell 43% of their total wheat straw; however, this percentage changed according to different parts of England and the variation was from 33.21% to 67.35%. for example, in the study of YANLI ET AL. (2010), from the total collectable amount around 73% can be used for energy purposes, in the study of CAI ET AL. (2008), this amount is 45% their results derivate based on statistical measurement, other authors who took into consideration the willingness of farmers to sell straw, the total available straw for energy (from collectable amount) was 38.1% and 46% (ALTMAN & SANDERS, 2012), 45% (GAUS ET AL., 2013), 43% (GLITHERO, RAMSDEN, ET AL., 2013), 16% (in renewable energy-driven province) and 37% (in coal-rich region) (ZYADIN ET AL., 2017).

Based on the results in figure 30 and 31 from the total amount of dry biomass, we can say that around 38% can be used for energy purposes, while in other studies, we can see a different percentage for available straw for energy 25%-27% from the total dry-biomass, without specifying much for other purposes (ALAKANGAS, 2011; FREAR ET AL., 2005; KARAJ ET AL., 2010; WEISER ET AL., 2014; WILLIAMS, 1995; YAMAMOTO ET AL., 1999)
The Collectable amount in our study is around 58% which came from harvesting straw at a cutting point of 15cm (which is also similar to daily practices by farmers); our finding is also in line with sustainable removal rate as it is quite similar to different papers. When it comes to collectable amount from the total straw, there are different discussions which are related to sustainable removal rate; for example, we can find different papers in which authors found the sustainable removal rate amount by referring to different literature review recommendations like CAI ET AL. (2008) and JINMING & OVEREND (1998) which was 60%, similar results are also found by DAIOGLOU ET AL. (2016) 50-60%, while 40% (ELBERSEN ET AL., 2014; MONFORTI ET AL., 2013), 50% (DE WIT & FAAIJ, 2010; DEES ET AL., 2017; FISCHER ET AL., 2010), 33-50% (SPÖTTLE ET AL., 2013; VALIN ET AL., 2015) the author also specified that this amount has to be removed every two to three years, 15-60% (SCARLAT ET AL., 2010) and max 70% (PUDELKO ET AL., 2013). While there are also papers that recommend a different percentage of the collectable amount which were measured based on the equipment used, for example, BOYDEN (2001) found that if straw is cut 20cm above the ground, then 60% of total dry biomass would be collectable, while if straw is cut 30 cm than around 47% is collectable. LAFOND ET AL. (2009) discussed that if straw is harvested at 10cm above ground, than 26-40% is collectable with bailing; in the study of OPOKU & VYN (2011) this amount was 50-57%, while SUARDI ET AL. (2020) reported a value of 46.5% and the last one is 50% by AHDB (2017). For example, HAKALA ET

AL. (2016) recommended that around 65% of straw can be collected, but this amount has to be collected every second year.

Our study's percentage of straw left on land (without counting 2cm above ground and roots) is 42%; this percentage is in line with the sustainable removal rate discussed above.

Chaff in our study represent around 26% of total dry biomass, similar results can be found in the study of SUARDI ET AL. (2020), where chaff represents 28% (1853kg/ha). In the study of LAFOND ET Al. (2009), the proportion of total aboveground residues other than grain was 55% for chaff and 45% for straw, while 30% chaff and 70% straw for COLLINS ET AL. (1990) and 33% chaff and 67% straw in the study of MCCLELLAN ET AL. (1986).

The uncut residues (stubble 13cm part) in our study represents 16% or 1631.8kg/ha, while in the study of SUARDI ET AL. (2020) is 20% (1617kg/ha), this percentage is lower than the findings of our study, this can be as a result that we did not count the amount of 2cm above the ground together with roots.

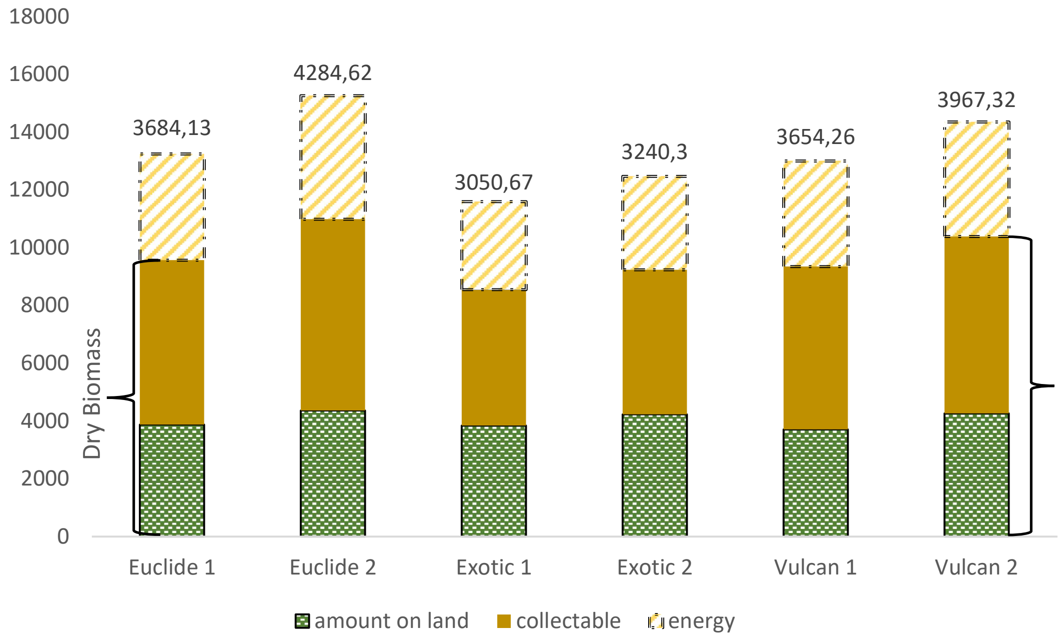


Figure 32. The Share of Total Dry Biomass (on Land, Collectable, Energy Purposes) Based on Cultivar, Region and Year kg/ha

Notes; 1. Kosovo Plain; 2. Dukagjini Plain

Source: authors' own calculation

As shown in figure 32, the highest amount of straw that can be used for energy purposes is from the cultivar Euclide. However, the difference between Euclid and Vulcan in the Kosovo plain are minimal.

Table 25. Total Dry Biomass, and its Share in Percentage Within a Wheat Plant (in gram)

Year	Type	Tot. biomass	Collectable straw	Chaff	Stubble
2019	Euclid	2.16 (100%)	1.22(56.48%)	0.62(28.70%)	0.32(14.81%)
	Vulcan	1.87 (100%)	1.06 (56.68%)	0.51(27.27%)	0.30 (16.04%)
	Exotic	2.03 (100%)	1.07 (52.71%)	0.62 (30.54%)	0.34 (16.75%)
2020	Euclid	1.84(100%)	1.15(62.5%)	0.42(22.82%)	0.27 (14.67%)
	Vulcan	1.56 (100%)	0.96(61.53%)	0.33(21.15%)	0.27 (17.31%)
	Exotic	1.68 (100%)	0.94(55.95%)	0.46(27.38%)	0.28(16.67%)

Source: authors' own calculation

Regarding table 25, from the total biomass within a wheat plant, only 53% to 63% can be used, while the other part 37-47% would stay on land, this part is undesirable and unable to collect which is in line with sustainable removal suggestion. In 2021, there is a lower amount of collectable straw; however, ratio between collectable straw to chaff is higher for collectable straw and lower for chaff; this is because chaff is affected more by changes than collectable straw. We can conclude that chaff has a share on total straw between 21-30.5%, and this part stays on land, besides chaff the other part which stays on land is around 15cm that cannot be baled, its share from total biomass is around 15-17% (without counting 2cm above the ground together with roots). We can find similar results in the study of SUARDI ET AL. (2020) from the total amount of harvested residues, chaff represented 28% (1853kg/ha), uncut residues 20% (1617kg/ha), from total residues around 46.5% (3710kg/ha) could be baled with a mean harvest index (i.e., the ratio between grain and total biomass) of 0.49.

5.3.5 Difference Between Cultivars and Regions (kg/ha), for 2019 and 2020

According to DONALDSON ET AL. (2001), Straw yield or straw to grain ratio can change based on the sowing date and sowing density; moreover, it depends on the type of cultivar (DONALDSON ET AL., 2001; LARSEN ET AL., 2012; PELTONEN-SAINIO ET AL., 2008; SKØTT, 2011) with taller cultivars showing greater variability (R. E. ENGEL ET AL., 2003). However, the effects of the environment and management appear to exceed those of genetics (JOSHI ET AL., 1995). Straw yield can also change depending on nitrogen and water availability (R. E. ENGEL ET AL., 2003), fungal infections and, therefore, fungicide treatment (JØRGENSEN & OLESEN, 2002). Amount of straw can also depend on straw harvesting point or type of combine harvester used (GLITHERO, WILSON, ET AL., 2013; SKØTT, 2011; STUMBORG ET AL., 2011), among other factors, ZYADIN ET AL. (2019) mentions that education of farmers and advanced machinery makes the use of straw for energy more attractive. There is considerable variation of straw to grain ratio between cultivars in literature. The large range of values is that there are several factors mentioned above that influence these ratios. LARSEN ET AL. (2012), in attempting to identify the cultivars with high straw yields for use as feedstock for biofuel production, found yields ranged from 2.7 t ha^{-1} to 4.2 t ha^{-1} in one field experiment and 3.4 t ha^{-1} to 4.6 t ha^{-1} in another (baled straw).

Table 26.Differences Between Wheat Cultivars and Regions for 2019 (kg/ha)

Parameters	a) Dukagjini Plain	b) Kosovo Plain	a-b	p-value
Seeds Eu	13,616.15[a]±3340.9	7961.18[a]±2056.61		0.000
Seeds Vu	11,506.94[b]±3213.3	6724.17[a]±1549.9		0.000
Seeds Ex	13,748.03[a]±3989	6887.77[a]±1933.14		0.000
Average	12,949.4±3665.8	7193.16±1932.3	44.45%	0.000
p-value	<0.05	>0.05		
Chaff Eu	3194[a]±949.2	2693.24[a]±857.3		0.000
Chaff Vu	2729.79[b]±786.8	1957.36[c]±447.6		0.000
Chaff Ex	3098.02[a]±795.8	2318.77[b]±475.8		0.000
Average	3005.59±0.16	2323.15+690.5	22.71%	0.000
p-value	<0.05	<0.05		
Collectable Straw Eu	7091.38[a]±1525.8	4711.27[a]±943.1		0.000
Collectable Straw Vu	6235.43[b]±1497.8	3750.77[b]±733.8		0.000
Collectable Straw Ex	5625.93[b]±1244.5	3818.17[b]±893		0.000
Average	6314.48±1544.5	4095.33±964	35.14%	0.000
p-value	<0.05	>0.05		
Stubble (13cm) Eu	1721.17[a]+492.1	1285.09[a]±344.31		0.000
Stubble (13cm) Vu	1671.5[a]±413.5	1083.43[a]±296.1		0.000
Stubble (13cm) Ex	1777.51[a]±371.1	1225.73[a]±402.4		0.000
Average	1723.19±429.1	1197.89±358.9	30.48%	0.000
p-value	>0.05	>0.05		

Note; means sharing common letters do not differ significantly from each other 5% probability level.
Source: authors' own calculation

Table 26 describes differences between three wheat cultivars and reagions during the year 2019. Results show that, the best cultivar during 2019 regarding seed and straw in the Kosovo Plain is cultivar Euclid, which has the highest yield of seed and dry biomass, the second one with the highest amount of seed and dry biomass is Exotic, and the last one is Vulcan. From table 28, we can see that during 2019 from the experiment in the Kosovo Plain, production of seed was around 6.7 to 7.9 tons per ha, from total straw, only 3.8 to 4.7 ton/ha can be used while chaff and the amount of 13cm will stay on land, in total this amount is around more than 3.5 ton, (without counting 2 cm and roots). During 2019 in the Kosovo Plain, the cultivar Euclid had the highest amount of seed, 7.9ton/ha and straw 4.7ton/ha. If we consider the willingness of farmers to sell straw, which is 64.73%, then, from the total average amount of collectable straw 4095.33kg/ha, only 2650.9kg/ha would be available to sell for energy purposes. From the total dry biomass 7616.37 kg/ha (without counting 2cm above the ground together with roots), only 53.8% is able to collect 4095.33kg/ha, while 46.2% (3521.04kg/ha) would stay on land (plus 2cm straw above ground together with roots). The best cultivar during the same year (2019) in the Dukagjini region regarding seed was Exotic, which was slightly higher than Euclid; however, these two were not significant. The cultivar Euclid had the highest dry biomass, which was significantly higher than cultivar Vulcan and Exotic. Vulcan had the lowest amount of seed which was significant; however, it can produce a higher amount of dry biomass than Exotic, but there was no significant difference. In the Dukagjini plain, the production of seeds was around 11.5 to 13.6 tons per ha, from the total straw, only 5.6 to 7.1 ton/ha is collectable while chaff (3ton/ha) and the amount of 13cm (1.7ton/ha) will stay on land, in total this amount is around 4.7 ton/ha, without counting 2 cm of straw above the ground which is unmeasured together with roots. If we consider the willingness of farmers to sell straw, this is 64.73%, then, from the total amount of collectable straw 6314.48/ha, only 4087.36kg/ha would be available to sell for energy purposes. From this, we can conclude that from the total dry biomass of 11,043.3 kg/ha (chaff, collectable straw, straw 13cm without counting 2cm above the ground together with roots), based on farmers' willingness to sell straw, only around 35% can be used for energy purposes. From the total dry biomass of 11,043.3 kg/ha, only 57% is able to collect (6314.48kg/ha), while 43% (4728.8kg/ha) would stay on land (plus 2cm straw above ground together with roots). According to ASSENG ET AL. (2020), annual wheat yields range from <1 t/ha/y when water or nutrients are limiting to >10 t/ha/y in cooler, well-watered (via high rainfall or irrigation), and mostly long-season (8 to 11 month) growing environment. In AHDB (2017) study, the amount of steam is 5.7t/ha, leaves and dead shoots 2.1 t/ha, chaff 2.1ton/ha and 9.4t/ha grain. In the study of SUARDI ET AL. (2020) grain yield were 7665-8477kg/ha, uncut residues (stubble 1416-1706), chaff (1853 kg/ha) baled straw 3710-3829kg/ha.

Table 27. Differences Between Wheat Cultivars and Regions for 2020 (kg/ha)

Parameters	a) Dukagjini Plain	b) Kosovo Plain	b/a(%)	p-value
Seeds Eu	9557.90^{a}±2682	10396.8^{a}±2718.8		0.035
Seeds Vu	9767.80^{a}±1856.4	9598.6^{a}±2461.5		p>0.05
Seeds Ex	9506.84^{a}±2185.05	10053.29^{a}±3262.36		p>0.05
Average	9610.85±2261.4	10016.1±2841.06	4.21%	0.062
p-value	<0.05	<0.05		
Chaff Eu	2340.84^{a}±607.3	2326.4^{a}±810.9		p>0.05
Chaff Vu	2407.7^{a}±878.9	2314.4^{a}±1030.42		p>0.05
Chaff Ex	2194.40^{a}±437.55	2634.50^{a}±738.5		0.000
Average	2314.31±670.1	2424.34±878.72	4.75%	0.096
p-value	<0.05	<0.05		
Collectable Straw Eu	6160.11^{a}±1179.1	6537.03^{a}±1474.7		p>0.055
Collectable Straw Vu	6021.87^{a}±1131.76	7599.3^{b}±2203.3		0.000
Collectable Straw Ex	4399.01^{b}±1079.8	5625.63^{c}±1317.8		0.000
Average	5527±1382.6	6590.79±1886	19.25%	0.000
p-value	<0.05	<0.05		
Stubble (13cm) Eu	1495.15^{ab}±319.42	1446.30^{a}±294.81		p>0.05
Stubble (13cm) Vu	1727.94^{b}±380.5	2084.6^{b}±1376		0.000
Stubble (13cm) Ex	1403.98^{a}±290.2	1503.7^{a}±386.3		p>0.05
Average	1542.36±358.1	1678.81±889	8.85%	0.017
p-value	<0.05	>0.05		

Note; means sharing common letters do not differ significantly from each other 5% probability level.
Source: authors' own calculation

The table 27 describes differences between three wheat cultivars and reagions during the year 2020. The best cultivar during the year (2020) in the Dukagjini plain was cultivar Vulcan, with the highest yield of seeds and straw; however, it was insignificant with Euclid. The second-highest amount of straw and seed had cultivar Euclid, and the last one was Exotic. From table 27, we can see that during 2020 from the experiment in the Dukagjini Plain, the production of seed was around 9.6 to 9.8 tons per ha seed, from the total straw, only 4.4 to 6.1 ton/ha can be used, while chaff and the amount of 13 cm will stay on land, in total this amount is around 3.9 ton/ha, (without counting 2 cm and roots). The table shows that the cultivar Euclid has the highest amount of straw (6.1ton), while Vulcan has the highest amount of seed (9.8ton/ha). Based on the table, we can conclude that from the total average of 5527 kg/ha collectable straw, only 64.73% can be used for energy purposes or 3577.63 kg/ha, which means that from the total dry biomass of 9383.67kg/ha, only 38.1% (3577.63 kg/ha) can be used for energy purposes. From the total dry biomass 9383.67kg/ha, 59% is collectable, while the other part of dry biomass, 41.1% (without counting 2cm above ground together with roots), would stay on land. The best cultivar regarding seed during 2020 in the Kosovo plain is cultivar Euclid, which has the highest yield of seed; on the other hand, cultivar

Vulcan has the highest amount of straw; however, this cultivar has the lowest amount of seed, but it was insignificant. From table 27, we can see that during 2020 from the experiment in the Kosovo Plain, the production of seed was around 9.6 to 10.4 tons per ha seed, from the total straw, only 6.5 to 7.6 ton/ha can be used while chaff and the amount of 13 cm will stay on land, in total this amount is around 4.1 ton/ha, without counting 2 cm and roots. Based on the table 27, we can conclude that from the total collectable straw of 6590.79 kg/ha, only 64.73% can be used for energy purposes or 4266.22 kg/ha.

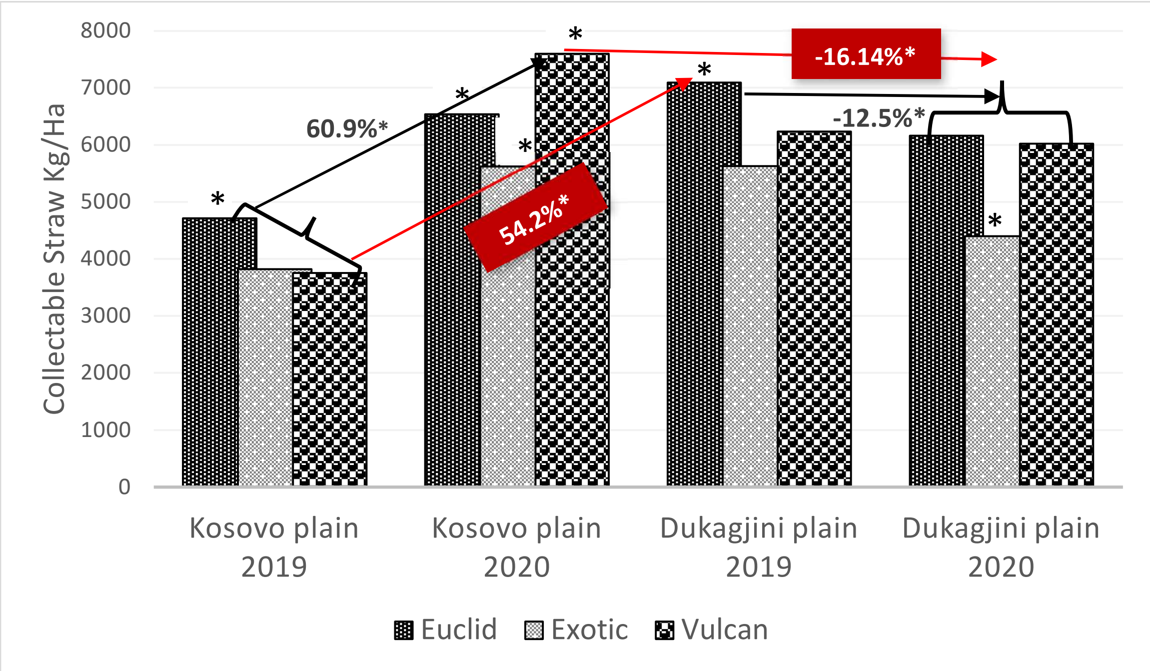


Figure 33. Collectable straw Based on Cultivar, Region and Year (kg/ha)

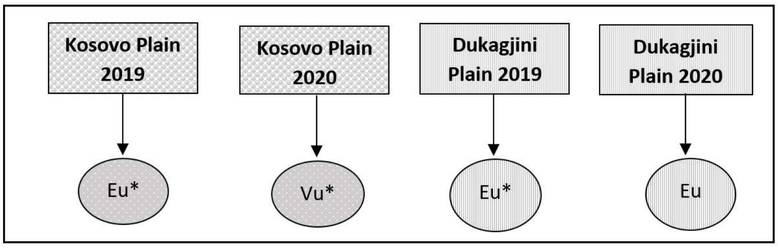


Figure 34. Best Cultivar of Year Within the Region, Regarding Collectable Straw

Source: authors' own calculation

The figure 33 and 34 shows that the best cultivar during 2019 in the Kosovo plain was Euclid, which was significantly higher than Exotic and Vulcan. Again, in the same region but different year 2020, the best cultivar was Vulcan, significantly higher than Euclid and Exotic. In the Dukagjini plain during 2019, the best cultivar was Euclid which was significantly higher than Vulcan and Exotic, and again in 2020 in the Dukagjini plain, the best cultivar was Euclid; however, it was not significant with other cultivars Exotic nor Vulcan. From both figures, we can see that cultivar Euclid was shown higher in straw and seeds; even though Vulcan and Exotic had higher seed in the Dukagjini plain 2019 and 2020, they were not significant to Euclid.

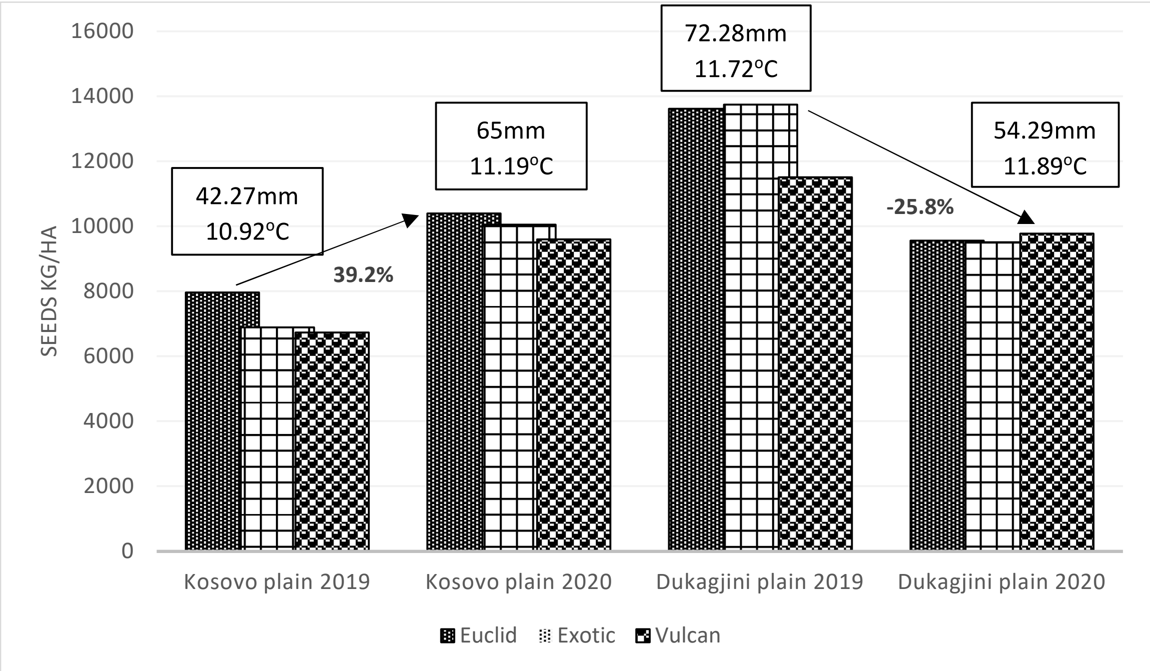


Figure 35. Wheat Yields Based on Cultivar, Region and Year (kg/ha)

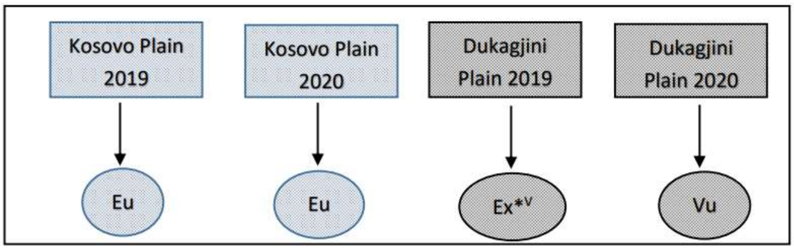


Figure 36. Best Cultivar of Year Within the Region, Regarding Seed
Source: authors' own calculation

From figures 34 and 35, we can see that cultivar Euclid regarding seeds was shown the best in the Dukagjini plain during 2019; however, it was insignificant with other cultivars like Vulcan and Exotic. Regarding 2020, again, the best cultivar was Euclid, however again, it was insignificant with Vulcan and Exotic. In the Dukagjini plain, during 2019, the best cultivar was Exotic; this cultivar was significant with Vulcan, which was the lowest one. However, there was no significance with Euclid. While in the Dukagjini plain 2020, the best cultivar was Vulcan, it was again insignificant with Euclid, but it was significant with Exotic, which was the lowest one.

Similar results about the inconsistencies over time of cultivars are found in the study carried by TOWNSEND ET AL. (2017) from 37 cultivars on field trials common to 2012, 2013, and 2014 field trials the cultivar *Pioneer variety 25R32* had the lowest straw yield in 2014, the fourth-highest in 2013 and the seventh-lowest in 2012. While *Syngenta SY 483* had the highest straw yields in 2014 and 2013 and the third highest in 2012 (TOWNSEND ET AL., 2017). The highest harvests of straw in Poland, 35.8 million tons, were recorded in 2014, and the lowest in 2000, 2003, and 2006 (respectively: 22.9, 24.0, and 23.4 million tons), which shows that they were characterised by significant fluctuations(GRADZIUK ET AL., 2020). Climatic conditions also have a large influence on straw yields; large-scale assessment of wheat straw yields. Under environmental and management conditions, HI can fluctuate significantly, particularly under adverse field conditions and crop stress, crop rotation, farming practices (e.g., soil cultivation, tillage), soil physical properties (BATIDZIRAI ET AL., 2016; GALLAGHER & BISCOE, 1978; LINDEN ET AL., 2000), fertilisers (YEVICH & LOGAN, 2003). When unfavourable conditions occur, straw yields are more heavily impacted than grain yields as the plant increases resource allocation to the grain (Linden et al., 2000). Wheat yield increased with an increase in irrigations (RAM ET AL., 2013). Both observed and simulated yields showed large temporal and spatial variability due to variations in climate and irrigation supply (increased irrigation has also increased the yields)(Chen et al., 2011). According to ASSENG ET AL. (2020), annual wheat yields range from <1 t/ha/y when water or nutrients are limiting to >10 t/ha/y in cooler, well-watered (via high rainfall or irrigation), and mostly long-season (8 to 11 month) growing environments.

5.3.6 Difference Between Cultivars Across the Two Years (kg/ha)

In the study of DAI ET AL. (2016), great variability in harvest index was detected within and between wheat classes; harvest index ranged from 0.33 to 0.61 in the study, averaged over all wheat classes and regions, the H.I was 0.45. HAKALA ET AL. (2009) claim that the amount of harvestable residue varies even within a crop species, according to the cultivation site and the variety of the crop. In the study of ROTH & STREIT (2018), dry biomass differed largely between species and samples. LARSEN ET AL. (2012) found considerable temporal variation, with 46% variation in the yearly averages, which was hypothesised to be a result of differences in weather between years.

Table 28. Differences Between Wheat Cultivars Across the Two Years in Kosovo Plain

Parameters	2019 (a)	2020 (b)	b/a(%)	p-value
Seeds Eu	7961.18±2056.6	10396.77±2718.8		0.000
Seeds Vu	6724.17±1549.9	9598.6±2461.5		0.000
Seeds Ex	6887.77±1933.1	10053.29±3262.4		0.000
Average	7193.16±1932.3	10016.1±2841.1	39.24%	0.000
Chaff Eu	2693.24±857.3	2326.43±810.91		0.000
Chaff Vu	1957.36±447.6	2314.36±1030.4		0.002
Chaff Ex	2318.77±475	2634.5±738.5		0.001
Average	2323.15±690.5	2424.34±878.7	4.36%	0.128
Collectable Straw Eu	4711.27±943.1	6537.03±1474.7		0.000
Collectable Straw Vu	3750.77±733.8	7599.3±2203.3		0.000
Collectable Straw Ex	3818.17±893	5625.63±1317.8		0.000
Average	4095.33±964	6590.79±1886	60.93%	0.000
Stubble (13cm) Eu	1285.09±344.31	1446.30±294.81		0.001
Stubble (13cm) Vu	1083.4±296.1	2084.6±1375.9		0.000
Stubble (13cm) Ex	1225.73±402.4	1503.7±386.3		0.000
Average	1197.89±358.9	1678.81±889	40.14%	0.000

Note; means sharing common letters do not differ significantly from each other 5% probability level

Source: authors' own calculation

Table 28 shows that a higher amount of total biomass was produced during 2020 in the Dukagjini plain. All three cultivars with all their physical parameters during 2019 were significantly different from those in 2020. On average, in 2020, the production of seed was higher at 39.24%, chaff for 4.36%, straw and leaves for 60.93% and stubble was 40.14%. From these findings, it is clear that the highest variability occurred in straw 60.93%, while the lowest was seed 39.24% and chaff 4.36%.

Table 29. Differences Between Wheat Cultivars Across the Two Years in Dukagjini Plain

Parameters	2019 (a)	2020 (b)	b/a (%)	p-value
Seeds Eu	13616.15±3341	9557.9±2682		0.000
Seeds Vu	11506±3213.3	9767.8±1856.4		0.000
Seeds Ex	13748.03±3989.4	9506.8±2185		0.000
Average	12949.40±3665.8	9610.85±2261.4	-25.8%	0.000
Chaff Eu	3194.03±949	2340.8±607.3		0.000
Chaff Vu	2729.79±786.8	2407.68±878.9		0.009
Chaff Ex	3098.02±795.8	2149.4±437.5		0.000
Average	3005.59±867.1	2314.31±670.1	-23%	0.000
Collectable Straw Eu	7091.38±1525.79	6160.11±1179.1		0.000
Collectable Straw Vu	6235.43±1497.8	6021.43±1131.8		0.272
Collectable Straw Ex	5625.93±1244.5	4399.01±1079.8		0.000
Average	6314.48±1544.5	5527±1382.6	-12.5%	0.000
Stubble (13cm) Eu	1721.17±492.7	1495.15±319.42		0.000
Stubble (13cm) Vu	1671.5±413.5	1727.9±380.5		0.332
Stubble (13cm) Ex	1777.51±371.1	1403.98±290.24		0.000
Average	1723.19±429.1	1542.36±358.1	-10.5%	0.000

Note; means sharing common letters do not differ significantly from each other 5% probability level
Source: authors' own calculation

Table 29, shows that a higher amount of total biomass was produced during 2020 in the Kosovo plain. All three cultivars with all their physical parameters during 2019 were significantly different from those in 2020, except straw in cultivar Vulcan. On average, in 2020, production of seed was lower at 25.8%, chaff for 23%, straw and leaves for 12.5% and stubble was 10.5%. From all this, we can see that the highest variability has occurred in seed 25.8%, while the lowest one in straw 12.5% and chaff 23%, however, if we sum straw and chaff, again we can say that changes in dry biomass are higher than in seeds. Thus, TOWNSEND ET AL. (2017) suggest that these ratios need to be calculated for individual cultivars and locations to predict straw yield from grain yield because of the variation with cultivar and location-specific factors. According to JOSHI ET AL. (1995), because of the large effects of environment and management on straw quality and quantity, it is necessary to undertake such studies over at least five years and at many locations. This needs considerable resource inputs even if applied only for varieties ready for release. In 2014 variety performance test of US wheat cultivars, straw yields ranged from 1.23 t ha^{-1} to 3.88 t ha^{-1} with an average of 2.67 t ha^{-1} (TOWNSEND ET AL., 2017). LARSEN ET AL. (2012) results indicate greater variability in straw yields than grain yields he also found a significant difference between cultivars.

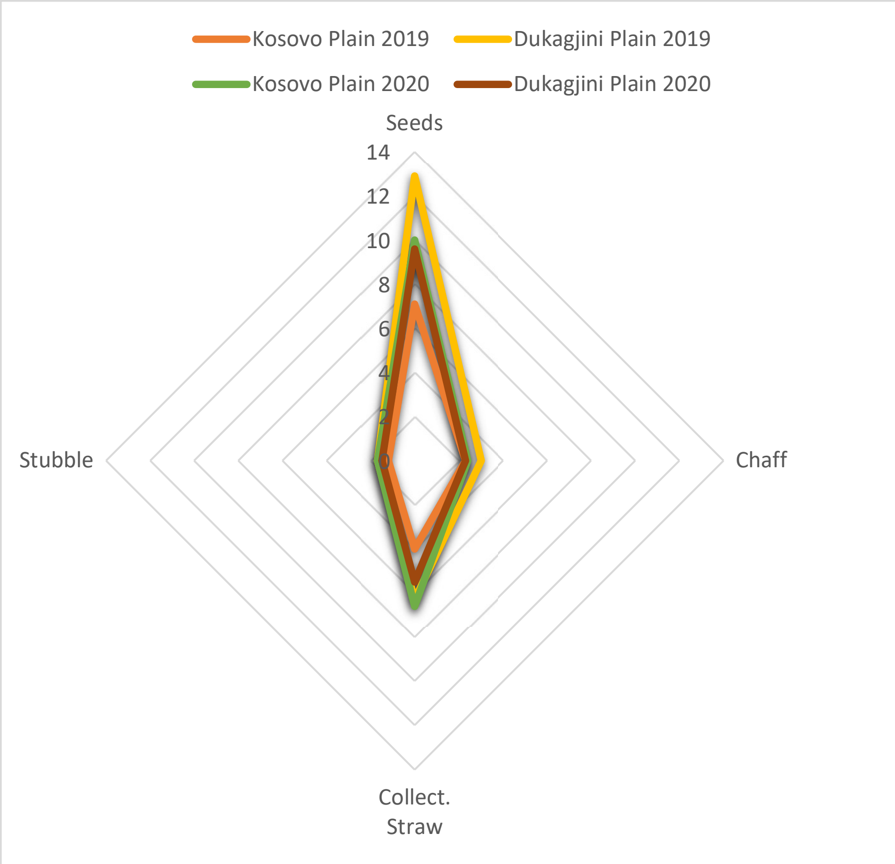


Figure 37. The Amount of Dry Biomass and Seeds Based Regions and Years (kg/ha)
Source: authors' own calculation

From figure 37, we can see that the highest amount of wheat biomass was in the Dukagjini Plain-Peje during 2019, and the lowest one was in the Kosovo Plain during the same year 2019; these are both extremes with each other. The year 2020 stands between these two extremes. Contrary to 2019, during 2020, the Kosovo plain had a higher amount of wheat biomass; however, the difference was slightly lower. In both years, the highest amount of seeds was found in the Dukagjini Plain during 2019, and the highest amount of straw was found during 2020 in the Kosovo Plain. As we can see, the amount of biomass can change every year and in different parts of wheat. The amount of wheat biomass per ha is highly dependent on the number of wheat plants; even though the amount of wheat in gram can guide us to find out the highest yield from a particular cultivar, the amount of wheat plants per ha can change that order. Cultivars with a high number of wheat plants would also bring a higher yield; this impact is also discussed in the study of BASTOS ET AL. (2020). While in the study carried out by CAO ET AL. (2019), spikes (in our case, wheat plants) per hectare of winter wheat were the most important component to the wheat yield.

Table 30. Differences of Wheat Biomass Between Two Years

Parameters	2019 (a)	2020 (b)	b/a (%)	p-value
Seeds	10020.07±4096.3	9812.03±2571.3	-2.1%	0.309
Chaff	2658.30±852.9	2368.93±781.9	-10.9%	0.000
Collectable Straw	5185.16±1695.4	6055.10±1734.1	16.8%	0.000
Stubble (13cm)	1455.87±474.1	1610.10±678.7	10.6%	0.000

Note; means sharing common letters do not differ significantly from each other 5% probability level.
Source: authors' own calculation

Table 30 compares two years, without separating them into regions. The results show that in general, during 2020 a higher amount of all the wheat parameters was produced, and it was significant, except seed. From 2019 to 2020, we can see a small decrease in seed around -2.1%; when it comes to chaff again, we can see a reduction of 10.9% in the amount, which was significantly lower in 2020 compared to 2019, while an increase in the amount of straw for around 16.8% was significantly higher in 2020 compared to 2019, same with the amount of straw which stays on land (straw and leaves 13cm).

5.3.7 Harvest index and ratio straw to grain, based on the cultivar, region and year

In the study of DAI ET AL. (2016), great variability in harvest index was detected within and between wheat classes; harvest index ranged from 0.33 to 0.61 in the study, averaged over all wheat classes and regions, the HI was 0.45. According to SCARLAT ET AL. (2010), the relationship between residue-to-seed production is very specific to the type of crop and plant variety. It is challenging to make a straightforward estimation of this ratio since it is influenced by climate and soil conditions and farming practices (tillage, density of planting, fertilisation, etc.). HAKALA ET AL. (2009) highlights that there is a reasonable relationship between yield and residue. Residue-to-grain ratios are often used to predict straw yield from grain yields for trials where straw yield has not been measured, usually assuming a direct or linear relationship between grain and straw yields (R. E. ENGEL ET AL., 2003). In the study of SUARDI ET AL. (2020), we can find a HI=0.49.

Table 31. Harvest Index and Straw to Residue Ratio Based on Cultivar, Region and Year

Parameters	Year	Euclid	Vulcan	Exotic	Average	Total Average
Harvest Index-Kosovo Plain	2019	0.478	0.498	0.483	0.486	0.50
	2020	0.502	0.444	0.507	0.485	
Harvest Index-Dukagjini Plain	2019	0.531	0.520	0.567	0.539	
	2020	0.489	0.490	0.545	0.508	
Collectable Straw to Grain, Kosovo Plain	2019	0.592	0.558	0.554	0.568	0.57
	2020	0.629	0.792	0.560	0.660	
Collectable Straw to Grain, Dukagjini Plain	2019	0.521	0.542	0.409	0.491	
	2020	0.645	0.616	0.463	0.575	
Total dry biomass to Grain, Kosovo Plain	2019	1.091	1.010	1.069	1.057	0.99
	2020	0.992	1.250	0.971	1.071	
Total dry biomass to Grain, Dukagjini Plain	2019	0.882	0.924	0.764	0.857	
	2020	1.046	1.040	0.836	0.974	
Total straw to Grain, Kosovo Plain	2019	0.753	0.719	0.732	0.735	0.73
	2020	0.768	1.009	0.709	0.829	
Total straw to Grain, Dukagjini Plain	2019	0.647	0.687	0.539	0.624	
	2020	0.801	0.793	0.610	0.735	
Willing to sell x Collec. Straw, Kosovo Plain	2019	0.383	0.361	0.359	0.368	0.371
	2020	0.407	0.512	0.362	0.427	
Willing to sell x Collec. Straw, Dukagjini Plain	2019	0.337	0.351	0.265	0.318	
	2020	0.417	0.399	0.300	0.372	

Source: authors' own calculation

From table 31, we can see various indexes generated based on cut point of straw, cultivars and willingness to sell straw. As it is shown, the Harvest Index (seeds/ seeds+ total dry biomass) can differ from cultivars, years and regions with a scope from 0.48 to 0.54. The lowest Harvest Index was found in the Kosovo Plain-Lipjan, even though it was different between cultivars and years, the average is similar in 2019 and 2020, while higher Harvest Index we can find in the Dukagjini Plain-Peja during 2019 the H.I=0.54, while in 2020 the H.I was slightly lower. After harvest index, the ratio straw to grain was calculated, the amount of straw in this index represents straw which is able to be collected by machinery, when machinery cuts it 15cm above the ground together with chaff, this type of index varies from 0.55 to 0.79, which an average of 0.57, which means from one kg of seed, 0.57kg of straw is able to be collected. When it comes to "Total dry biomass" or the ratio between total dry biomass and seed, the index is 1:1, which means for every kg of seed, around 1 kg of dry biomass is produced; total dry biomass represents the total dry matter of biomass (the total straw which is cut 2cm above the ground together with chaff). The other one is "total straw" and represents straw which is cut 2cm above the ground, without chaff the ratio number varies from 0.54 to 0.83 with an average of 0.73, which means if the machinery cuts straw 2cm above ground without chaff, for every kg of seeds, we will have around 0.73kg straw, however cutting straw in this way is not sustainable. The last parameter which we calculated is collectable straw and the willingness of farmers to sell it; this parameter is based on the willingness of farmers to sell straw from straw which is able to collect. From collectable straw, farmers are willing to sell around 64.73% of it. This ratio number is found as collectable straw * willingness of farmers to sell straw divided by kg of seeds. The ratio numbers differ from 0.27 to 0.51 with an average of 0.37, which means based on farmers' willingness to sell straw, per every 1 kg of seed, only 0.37kg of straw can be used for energy purposes.

Table 32. Potential of wheat biomass in Kosovo

Amount of dry biomass	Kosovo Plain (2019-2020) kg/ha	Dukagjini Plain (2019-2020) kg/ha	Average kg/ha	Land with wheat (80,273 ha) ton
Total Dry Biomass	9133.3	10204.53	9668.9	776,151.6
Total Straw	6760.3	7548.3	7154.3	574,297.1
Collectable Straw	5325.36	5916.5	5620.93	451,208.9
Willing. to sell **x** collec. straw	3447.1	3829.75	3638.43	292,067.7
Seeds	8584.61	11262.17	9900.74	794,762.5

Source: authors' own calculation

In Kosovo, around 80,273 ha are planted with wheat. From the table above (table 32), based on our experiment, we found out that if straw is cut 2 cm above ground, Kosovo has the potential to produce around 574,297.1 tons per year. However, cutting wheat at the point of 2cm above ground is not sustainable; thus, we calculated the amount of straw with the cutting point 15cm above ground; in this way, we would gain around 451,208.9ton; however, when we consider the willingness of farmers to sell straw for energy purposes this amount is reduced to 292,067.7ton/year as in general, farmers wanted to sell around 64.73% of their straw. We calculate 292,067.7 tons, and the average price is €0.57/15-kg bale. The price for a ton would be 38 euros, and in total, farmers would generate 11 million euros. Similar price €32 per ton we can find in the study of MARKS-BIELSKA ET AL. (2019), and the amount that farmers would generate would be 4.3 million euro. By processing the surplus straw into pellets, its value would increase to around 8 million euro as the price for pellets was calculated approximately 193 $€\cdot t^{-1}$. However, wheat yield ton/ha in agriculture households is lower than in experiment. In order to improve straw availability. BATIDZIRAI ET AL. (2016) suggest no-till cultivation, improving animal feed conversion efficiency, improving agricultural management systems, and using contractors to collect residues where they are currently burned.

Table 333. Biomass Assessment Based on Different Literature Review

AUTHORS	R%	AUTHORS	C %	AUTHORS	S%	AUTHORS	W%	AUTHORS	A%
(KONVALINA ET AL., 2014)	1.24-1.91	(BOYDEN, 2001)	35–60	(SPÖTTLE ET AL., 2013; VALIN ET AL., 2015)	33-50	(GLITHERO, RAMSDEN, ET AL., 2013)	33.21-67.35	(WEISER ET AL., 2014)	27
(CAI ET AL., 2008; GRADZIUK ET AL., 2020; J. J. LI ET AL., 2001; SAHITI ET AL., 2015; ZHANG ET AL., 2019) (W. WANG ET AL., 2020)	1 1.2	(AHDB, 2017)	50	(PUDELKO ET AL., 2013) (ZHANG ET AL., 2019)(STATISTICS)	70 24	(ALTMAN & SANDERS, 2012)	38.1 and 46	(ALAKANGAS, 2011; FREAR ET AL., 2005; KARAJ ET AL., 2010; WILLIAMS, 1995; YAMAMOTO ET AL., 1999)	25
(SINHA ET AL., 1982)	1.30-3.20	(LAFOND ET AL., 2009)	26-40	(DEES ET AL., 2017) (FISCHER ET AL., 2010) (DE WIT & FAAIJ, 2010)	50	(GAUS ET AL., 2013),	45		
(H. LI ET AL., 2017)	0.93-1.38	(OPOKU & VYN, 2011)	50-57	(DAIOGLOU ET AL., 2016) (SCARLAT ET AL., 2010)	50-60 15-60	(ZYADIN ET AL., 2017)	16 and 37		
(SUARDI ET AL., 2020) (BALED STRAW) (YANLI ET AL., 2010)	1: 0.43 0.73	(SUARDI ET AL., 2020)	46.5	(ELBERSEN ET AL., 2010; MONFORTI ET AL., 2013) (YANLI ET AL., 2010)	40 76%	MARKS-BIELSKA ET AL. (2019) AFTER HARVEST (CALCULATED) (YANLI ET AL., 2010) (CALCULATED)	50% 73%	(YANLI ET AL., 2010)	62
(SUARDI ET AL., 2020)	1:0.94	(HAKALA ET AL., 2016)	65	(CAI ET AL., 2008; JINMING & OVEREND, 1998)	60			(CAI ET AL., 2008)	60
Author's Own Calculations	**1:1**	**Author's Own Calculations**	**58%**	**Author's Own Calculations**	**58%**	**Author's Own Calculations**	**64.7%**	**Author's Own Calculations**	**37%**

R-ratio straw/residue from total straw (recommended or used on current studies), **C**- Collectable amount of straw with equipment used, **S**- Sustainable removal rate; recommended or used, **W-** Willingness to sell straw, from straw removed, **A**- Available straw for energy purposes (statistical measures).

Note; (our results show that from the report 1:1, we can collect 58% of straw, and from these amount farmers are willing to sell 64.7%. Or from the report 1:1, only 37% of residues can be used for energy purposes)

In studies by different authors (presented on table 33), the amount 25% of straw for energy purposes was calculated statistically based on the report straw/grain. In the study by MARKS-BIELSKA ET AL. (2019) the amount of straw for energy purposes was calculated by subtracting the amount of straw used in agriculture, namely for bedding, feeds and maintenance of a balanced content of organic substance in soil, however it is unclear how much straw stays on land together with stubbles and amount of collectable straw, according to their study, from theoretical capacity around 50% of straw can be used for energy purposes. Similar results we can find on CAI ET AL. (2008) results, whose calculations were based on statistical method, he used the report grain to straw 1:1, the amount which stays on land 40% and the amount the potential amount for energy purposes 60%, without counting the willingness of farmers to sell straw. In the study of YANLI ET AL. (2010), the report grain to straw was 1:0.73, from the total amount of residues around 76% was considered collectable, from the collectable amount around 73% was considered that can be used for energy purposes and 27% for other use. Based on their calculations from the total amount of residues $5.33X10^8$ ton around 3.31x108 can be converted to energy, or 62%.

6 CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

1. From this study, we conclude that non-farm income plays a vital role in total household income. According to farm type classes, complemented part-time farming (type 2) fare best regarding per capita incomes. This difference may be explained due to the high share of non-farming income compared to full-time farms $p<0.05$ and because of farm income per hectare of land on type 2, which is the highest, but still, is insignificant. According to per capita income, full-time farms are the poorest; even though they have higher income per ha than subsidiary farms, their disadvantage stays on the lowest share of non-farm income $p<0.05$. The wealthiest groups are characterized by a higher share of education, household size, and off-farm income. Middle-income households seem to be characterized by their ability to find alternative employment in the non-farm sector, allowing them to compensate for low farming income. According to the impact that non-farm income and unearned income have, non-farm income lifts 16% of households out of poverty, and the effect of unearned income is lower, about 2.7-3.45%. At the Gini coefficient, which was calculated without considering non-farm incomes, we found a notable increase, namely 0.699. On the other hand, the total Gini was 0.452; this implied that non-farm income contributes to equal income distribution in rural areas.
2. Circular economy regarding Renewable Energy is socially desirable as around 91.3% of farmers are willing to sell the straw, the average amount of selling the straw based on farmers' willingness, was 64.74%. Regarding farmers' attitude to selling biomass from wheat straw and the practice of straw burning, we have determined what conditions are necessary to avoid burning straw on the field and thereby wasting valuable energy. The results indicate that a specific market price and a contractual relationship determine the willingness to sell straw. The most critical issues that we clarified during our study are factors that influence sale of extra straw among farmers. Results have shown that livestock farming significantly influences the willingness to sell straw. Farmers who produce both wheat and corn see the same market opportunities for both by-products. It is also clear that small or part-time farmers are much more willing to sell than large farmers or those who work full-time in agriculture. This is presumably due to the lower production risk. The analysis also showed that soil nutrient supply issues do not influence farmers' decisions, so this would not have influenced their decision to sell straw at the time of the survey. This research also demonstrates the need to incorporate sales constraints (state regulators) into

the market system to avoid overselling straw. An interesting finding is that younger farmers respond flexibly to new sales opportunities, while older farmers prefer to use traditional livestock farming. The survey found that level of education does not influence how much a farmer chooses to sell. However, we found that farmers with a higher level of education were more willing to sell over 50% of their straw, meaning that they would become part of the energy biomass market. We have statistically demonstrated that the three significant factors influencing wheat straw sales need to be examined to understand the relationships affecting willingness to sell.

3. Farmers' production of corn and the by-product thereof increases their willingness to sell straw. In short, if a farmer produces corn in addition to wheat, s/he will sell wheat straw together with corn straws as they are positively correlated. When farmers are engaged in animal husbandry, a significant factor is always the amount of straw needed for bedding. The effect on economic size is significant, so if the economy is larger, farmers are willing to sell more straw to a bioenergy market, and a well-functioning market will greatly influence the activity and number of its participants. The study details show that a good market structure that promotes biomass for energy would increase farmers' income, reduce emissions from open field burning, and help achieve efficient energy recovery of field waste biomass (wheat straw). Based on the study results, it is possible to outline the directions of sustainable biomass energy utilization and development for policy-makers, on the basis of which an efficient subsidy system and market instruments can be developed for the given region. The research results are also worth highlighting because most of the countries in southeastern Europe are not yet EU members. The regulations related to open field burning vary and, as in Chinese agricultural practice, may be associated with a significant environmental problem that will also increase GHG emissions in the near future.
4. From the analysis regarding the experiment, we can conclude that the cultivar with the highest amount of seed and dry biomass was Euclid; however, its seeds were significant with Vulcan in both regions but not with Exotic cultivar, while its straw was insignificant with any of the cultivars in both regions. The second one with the highest amount of seed was Exotic, and the second one with the highest amount of dry biomass was Vulcan. From the two-year experiment (2019-2020), we can conclude that the Dukagjini plain has a significantly higher amount of seed and dry biomass than the Kosovo plain.
5. The best cultivars regarding seed- The best cultivar in the Dukagjini plain during 2019 was Exotic; however, it was insignificant compared to Euclid. In 2020 the best cultivar in the Dukagjini plain was Vulcan; however, it was not significant with other cultivars. The best cultivar during 2019 and 2020 in the Kosovo plain was Euclid and was significantly higher

than other cultivars, while in 2020, it was not significant. As we can see, there are best cultivars but not significant, except Euclid in the Kosovo plain during 2019.

6. The best cultivars regarding straw- The best cultivar in the Dukagjini plain during 2019 and 2020 was Euclid, also it is worth noting that in 2019 Euclid was significantly higher compared with other cultivars regarding straw. In the Kosovo plain during 2019 again, Euclid was significantly higher, while in 2020, Vulcan was significantly higher. After comparing all cultivars in two years, we found out that cultivar Euclid has higher seed and dry biomass in both regions; however, this was not significant in most of the parameters.
7. The amount of biomass in cultivars can change depending on year and region; for example, in the Dukagjini plain during 2019-2020, the amount of seed and straw decreased significantly, 25.8% for seed and 12.5% for straw. In the Kosovo plain, the amount of seed and straw was increased from 2019 to 2020 significantly; seed increased 39.24%, while straw 60.93%. We also have similar variations between Dukagjini and Kosovo plains, if we calculate the amount of biomass in both years, the Kosovo Plain has a significantly lower amount of seed 23.8%, and straw 10% compare to the Dukagjini Plain.
8. The highest and significant correlation between parts of a wheat plant is found between seed and total straw (which is cut 2cm above the ground) in gram; the correlation is positive $R^2=0.627$ $p<0.01$. The second strongest correlation we can find between seed and chaff (in gram) correlation is positive and significant ($R^2=0.609$, $p<0.01$). Following this, seed and spike (in cm) has a significant positive correlation <0.01, while the correlation between seed and straw (cm) is insignificant $R^2=0.19$.

   Only 53-63% can be used from the total wheat plant, while the other part (uncut residues consisting 15 cm height above the ground plus chaff) would stay on land. Chaff has a share of 21-30.5% from a wheat plant, while the part of 13cm has a share of 15-17% from the total biomass (2cm of straw and roots are not measured). The average of the Harvest Index is 0.50, while the average of collectable straw to grain is 0.57. After considering the farmers' willingness to sell straw, the ratio of straw to residue decreased to 0.37. From this, we can say that 37% of total dry biomass, with farmers' willingness, can be used to produce sustainable energy. While the ratio between seeds and total dry biomass is 1:1. The Dukagjini plain can produce 3829.8 kg/ha straw for energy purposes, while the Kosovo plain 34471.1kg/ha. In total, the available biomass for sustainable energy purposes in Kosovo is 451,208.9 tons (straw which is cut 15cm above the ground without chaff), without counting the losses per ha.

6.2 Recommendations

1. As non-farm income contributes to a more equal income distribution in rural areas, the study recommends that public institutions need to support farmers through the provision of extension services and government subsidies to improve farm production and income of farmers. Yield enhancing inputs should be a possible intervention area to support rural households produce beyond the subsistence level. Efforts should also be in improving the skill and knowledge of farmers through provision of training, a specialization in the labour market and implementation of the 'circular economy' across the agro-food sector might indirectly play an important role for income diversification. A circular economy with a focus on renewable energy can be considered as a potential source of non-farm income by recycling or reusing agricultural wastes, which could lead to sustainable poverty reduction.
2. Regarding the analysis of farmers' attitudes towards the use of straw as renewable energy, it is first highlighted that naturally, high market price of straw can negatively impact livestock production and a regulatory environment that does not substantially influence the amount of straw used in livestock farming. Thus, in an examined farming environment, a complex set of objectives is formed, according to which a part of the produced straw must be provided in quantities and at prices that are available for animal husbandry. The environmentally friendly treatment of surplus straw (avoiding burning in the field by all means) should be directed to attractive market conditions. In addition to wheat straw, corn straw has a significant impact on the market for bioenergy derived from biomass.

3. As farmers tend to sell more than half of the biomass while the incorporation rate does not meet the sustainable requirements, incentives towards bioenergy production must be increasingly integrated with sustainability practices if policymakers achieve combined food and energy security goals. In order to avoid the practice of burning agricultural residues (straw) in the area under study, we need to have a proper market structure and well-regulated contractual terms. This means that number of active farmers will increase significantly if appropriate sales channels are created in the given market environment. Environmentally friendly treatment of surplus straw (avoiding burning in the field by all means) should be directed to attractive market conditions. In addition to wheat straw, corn straw has a significant impact on the market for bioenergy derived from biomass. Therefore, care should be taken to ensure that the improvement of market opportunities for wheat straw and positive change in the market conditions for corn straws do not diminish supply of livestock straw. This research also demonstrates the need to incorporate sales

constraints (state regulators) into the market system to avoid overselling straw. Based on the study results, it is possible to outline the directions of sustainable biomass energy utilization and development for policy-makers, on the basis of which an efficient subsidy system and market instruments can be developed for the given region. Research results are also worth highlighting because most of the countries in southeastern Europe are not yet EU members. Regulations related to open field burning vary and, as in Chinese agricultural practice, may be associated with a significant environmental problem that will also increase GHG emissions in the near future.

We also found a potential supply in the future from modernizing animal farms: bedding straw could be used for energy purposes, while another option to increase the capacity of biomass energy is planting perennial energy crops on marginal soils which can also increase and restore its fertility. Grass could be another option as a partial substitute for other biomass. However, institutions' intervention is necessary to push farmers to incorporate part of their straw into the land.

4. The government needs to allocate a budget to pellet factories and to farmers. Pellet factories can act as intermediator, thus there is a need to subsidize purchasing of straw baling machinery. Monitoring and accountability needs to be employed as well. Inspection teams has to be established to monitor illegal burning. The other option is to invest in local district heating. To encourage farmers to engage in sustainable practices and to take responsibility for their actions, there is a need to subsidize the cost of stubble incorporation into land, and in the future it is possible to use the last known spray which is released by Indian Agricultural Research Institute (IARI) (Pusa bio-decomposer solution, started to be used on 10 october 2020 by the Dehli Governemnt) to convert stubble into fertilizer in cheap and short time, however more scientific studies are needed regarding this. Furthermore, individual farmers need to sign liability assurance to abolish burning.

5. In the case of Kosovo, our study recommends using the ratio between straw to seeds of 0.37, which means for every kg of seeds, around 0.37kg of straw is available for energy purposes; this came after calculating collectable straw from land and farmers willing to sell it for renewable energy purposes. As straw can change year to year and region to region significantly, we recommend measuring straw by precision technologies to have the exact amount of straw in future and a yearly list with wheat cultivars with yield and straw reports is needs as yearly database. If this biofuel market develops, there will likely be an increase in demand for wheat straw from pellet producers/power plant stations and farmers who use straw in the livestock sector. In this way, higher land areas would be cultivated with wheat,

and the country can also increase self-sufficiency with wheat as is low until now. Creating this market, another benefit would be that farmers stop burning the residues on land, which is also risky for burning forest.

6.3 Limitations

Regarding the analysis with non-farm income, the research is limited due to its sample size. Data collection focused on farmers with different cultures (vegetables, small fruits), which led to heterogeneous overall results. We found that part-time farmers had a significantly higher income per hectare than full-time farmers; thus, analyzing this difference in incomes per hectare based on farm type needs further research and analysis. While limitations on the analysis with farmers' attitude, our study does not cover all possible topics within the biomass utilization but is limited to what we consider important in farmers' attitude. The research does not represent farmers' attitudes to biomass energy market, but the results identify the dominant tendencies of the market community. The amount of wheat biomass is based on the experiment monitored by experts; the results of ton/ha are based on a 1-m2 edge-protected experimental area and not from farm fields, which can be lower. A greater range of cultivars needs to be assessed in the future, with a more extended period.

7 NEW SCIENTIFIC RESULTS

Our study is the first one in the international literature review, which assess wheat biomass-based of agronomic measurements and willingness of farmers to sell straw, taking into consideration sustainability of straw removal rate. The study also considers the inequality between rural households and the impact of non-farm income on inequality and poverty.

In connection with the results of this study which had been presented, the novel scientific outcomes drawn from this research are as follows:

1. Based on my analysis, which is done by using Poverty (FGT) and Gini Indexes, extra income does not increase inequality; on the contrary, they slightly reduce inequality and contribute to softening poverty between farmers, which could help reduce migration from rural to urban areas. By using One-Way ANOVA to compare three groups of farmers based on their income, the results showed that the poorest rural households had the highest share of farm income (77.52%) since they were less able to respond to attractive emerging non-farm income, and hence had less diversified incomes opportunities, $p<0.05$. Non-farm incomes have a positive impact on poverty alleviation, thus, the study suggests adopting suitable rural policies to enhance nonfarm employment. Thus, extra income from renewable energy would positively affect poverty, which would lead to a sustainable poverty reduction. By using descriptive statistics which are taken from the face to face questionnaires, I conclude that farmers have positive attitudes regarding selling straw for energy purposes; the main reason for not selling straw was lack of market and machinery, while the main incentives were having a good price and guaranteed market.

2. By using Binary Logistic Regression, I conclude that factors which are significant and shaped in the percentage of willingness to sell straw are experience with selling straw, (was positively correlated with willingness to sell straw), having animals has negative correlation on willingness to sell straw, farm type: farmers who planted wheat and corn are less willing to sell straw compared to farmers who cultivate only wheat. Engagement in agriculture also significantly impacts willingness; part-time farmers are more willing to sell straw than full-time farmers. While soil concerns, age, land size with wheat, land size with corn, education and family size have no significant impact on the willingness of farmers to sell straw.

3. From the results of experiment which was carried out for two years consecutively in two regions with three most used winter wheat cultivars, I conclude that from the total biomass, if it is cut 15cm above the ground, around 58% of it is able to collect while the other part of 41.7% would

stay on land (without counting 2cm above the ground together with roots), this rate also supports sustainable removal rate suggested from different authors. The amount of dry biomass which stays on land contains 26% chaff and 16% stubble. From the collectable amount of straw, based on the willingness of farmers to sell straw, only 64.7% is available for energy purposes, converting in kg per ha this amount in the Kosovo plain is 3447.1kg/ha while in the Dukagjini plain, this amount is 3829.8.

4. From experimental fields, based on statistical analysis such as; One-Way ANOVA and T-test, there is significant difference of straw between cultivars, years and regions. Difference on the amount of collectable straw between two years within a region was from 12 to 37.9%, difference between regions for the first and second year of experiment was from - 16.14% to 35.14%. While in total territory, the difference on the amount of collectable straw for two years is 14%. The results of Pearson Correlation shows the strongest correlation with seeds had wheat straw (g) and total dry biomass (g) which was positive 0.627 and 0.654, significant at value $p<0.01$, while a lower correlation was found with plant height (cm) $p<0.01$ and straw(cm) $p>0.05$. In our study, the best predictors for the amount of straw are yields. The average harvest index is 0.50, and the average report of total dry biomass to grain is found to be 1:1; from this report, based on collectable straw and willingness of farmers to sell straw, we can say that for every kg of wheat, around 0.37 kg of straw can be used for energy purposes.

8 SUMMARY

The motivation of this thesis is based on several conditions which are causing high air pollution. Agriculture and electricity are among the most important sources contributing 11 % and 31% of the total human-generated greenhouse gas emissions (Global Emissions, 2020). Kosovo is one of the poorest countries in Europe. Based on the data from Eurostat regarding Kosovo, when it comes to energy for electricity, only 5.14% comes from renewable sources, which means that electricity from coal is 94.86%, one of the highest shares of coal compared to its neighboring countries. Kosovo reached the target of 25.69% from the directive of the EU and made a voluntary target of 29.47%. However, from the achieved target from overall GFCE, 23.89% is from biomass for heating purposes, and 1.8% is from renewable electricity.

On the other hand, there are reports that this biomass is not sustainable due to the high amount and illegal forest cuttings, except these, there are several residue burnings associated with forest burning and air pollution. Thus based on different literature review, we considered that using residues from biomass (wheat straw) for heating energy and creating a potential market would help transition from coal to renewables. Several authors claim that social equity is usually absent on the CE concept, including unequal distribution of wealth, income and labour conditions. Selling straw is considered as an extra non-farm income. There are countries where non-farm income causes inequality between farmers' households. Thus, in the first part of our study, we analyzed if non-farm income create inequality in Kosovo's case. Our second purpose was to specify the amount of straw available for energy use from different cultivars; however, several factors determine the amount of straw; as a result, it can change significantly within cultivars, within years and between regions. Studies in social science fields usually overestimate amount of straw; this is caused because they miss the part of agronomic measurement and willingness of farmers to sell straw.

Thus, authors refer to various national and international statistics related to ratio of straw to grain, and availability of straw for energy purposes, which usually is considered around 25%, while around 40-60% has to stay on land in order to be sustainable, however, the two cases which are not specified together is how much cm farmers need to cut straw to meet this criterion and what is the willingness of farmers to sell straw. Our study gives a clear picture regarding straw measurement based on farmers' attitude and agronomic condition. **Methodology**: The methodology of the thesis is made of data from interviews and experiment. The experiment with three repetitions is done in two regions (Kosovo plain and Dukagjini Plain) with three cultivars.

The researchers collected the data through personal interviews, during visits to the respondents' homes or workplaces, in the mill building "Jehona", and agriculture pharmacies. The first study was conducted during spring 2017. Our sample area consisted of five regions and seven municipalities within those regions. In total, the survey covered 203 heads of farm households. Farmers engaged in cultivation of various vegetables and small fruits were chosen using a random sampling technique. The applied structured questionnaire contained several customized modules capturing, among other things, farming activities, all sources of income, and driving forces of income diversification. In the second study, the focus was only on farmers who cultivate wheat; the questionnaire contained questions regarding socioeconomic factors, farm profile, practice of using straw, and their willingness to sell straw. Collection of these data was done from May–October 2019. Data were collected by applying a semi-structured questionnaire. They were distributed to 206 farmers in country. Data was examined with the statistical package for social sciences (SPSS).

One way Anova was used to analyze more than two independent variables (comparison of three income classes of farms and three cultivars in the experiment), and independent sample t-test in cases with two independent variables (comparison of wheat cultivars between two regions). We used poverty decomposition techniques - Foster, Greer, and Thorbecke (FGT) (Foster et al., 1984), which can be used to observe the effects of nonagricultural income on poverty, as well as widely known and used measure for inequality, the Gini coefficient. Binary logistic regression was used to check significant factors influencing the percentage of straw that farmers are willing to sell for power plants. **Results**: In Kosovo's case, extra income does not increase inequality, contrary they contribute to softening poverty between farmers, which could help reduce migration from within the country and from rural to urban areas. The results showed that the poorest rural households had the highest share of income from farm activities (77.52%) since they were less able to respond to attractive emerging non-farm income, and hence had less diversified income opportunities, $p<0.05$. Thus, the study suggests adopting suitable rural policies to enhance nonfarm employment, extra income from renewable energy would have a positive effect on poverty, which would lead to a sustainable poverty reduction. Farmers relatively have positive attitudes regarding selling straw for energy purposes; the main reason for not selling straw was lack of market and machinery, while the main incentives were having a good price and guaranteed market. From the total sample, farmers would sell around 64.73% of their straw Factors which are significant and shaped in the percentage of willingness to sell straw are experience with selling straw, (was positively correlated with willingness to sell more than 50% of straw), having animals has a negative correlation on the willingness to sell straw more than 50%, farm type: farmers who planted wheat and corn are less willing to sell straw compared to farmers who cultivate only wheat, Engagement in agriculture also has a significant impact on willingness, part-time farmers are more willing to sell straw more than 50%. While soil concerns, age, land with wheat, land with corn, education, and family size have no significant impact on the willingness of farmers to sell straw more than 50%.

From the experiment which I conducted, I conclude that the amount of straw and seeds can change yearly within a region and between regions, also the amount of straw between cultivars changes within a region and between regions, however as an average, the cultivar Euclid in Kosovo has shown the best results. However, in most parameters, the difference was insignificant with other cultivars in the experiment. The Dukagjini plain had a significantly higher amount of seed and dry biomass compared to the Kosovo plain. From the total biomass around 58% of it is able to collect which is in line with the rate mentioned from different authors, while the other part of 41.7% would stay on land (without counting 2cm above the ground together with roots). The amount of dry biomass which stays on land contains 26% chaff and 16% stubble. From the collectable amount of straw, based on the willingness of farmers to sell straw, only 64.7% is available for energy purposes, converting in kg per ha this amount in the Kosovo plain is 3447.1kg/ha while in the Dukagjini plain, this amount is 3829.8. From the total straw, we can say that only 37.5% is available for energy purposes, or for every kg of wheat, around 0.37 kg of straw can be used for energy. The correlation between straw and seed was positive 0.67 and significant at a value $p<0.01$. As straw can change from year to year and region to region significantly, we recommend measuring straw by precision technologies.

9 APPENDICES

9.1 Appendix (1) References

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9.2 Appendix (2) Applied agro-technical measures in field experiments

All agro-technical measures applied during the wheat cultivation period, for the vegetation of 2018/2019 in the two localities (Dukagjini and Kosovo Plain) are presented as follows:

Table 1. Applied agro-technical measures in Dukagjini plain during 2019

AGROTECHNICAL MEASURE	Location- Dukagjini plain/ Peja
Previous crop:	Potato
Plough	15.10.2018
Fertiliser	NPK 7:20:14+5% SO3, 400kg/ha, on date 17.10.2018
Power harrow, Roll after drilling, measuring and dividing fields.	18.10.2018
Sowing date	19.10.2018
The first re-fertilization	Urea 46% N, 200 kg/ha 20.02.2019
First treatment with insecticide	Lamdex [R] 50 SC, 200 ml/ha, and fungicid Falcon, 500 ml/h on date: 16.04.2019
Second treatment with herbicide	Secator OD, sasia 150 ml/ha, dhe Furore Super, sasia 800 ml (on date: 26.04.2019
The second re-fertilization	NAG 27% me sasi 200 kg/ha, on date: 06.05.2019
Harvesting of wheat plots	12.07.2019

Table 2. Applied agro-technical measures in Kosovo plain during the year 2019

AGROTECHNICAL MEASURE	Location- Kosovo plain/ Lipjan
Previous crop:	Maize
Plough	22.10.2018
Fertiliser	NPK 15:15:15, 400kg/ha, on date 24.10.2018
Power harrow, Roll after drilling measuring and dividing fields.	25.10.2018
Sowing	26.10.2018
The first re-fertilization	Urea 46% N, 200 kg/ha on date 21.02.2019
First treatment with herbicide	Secator OD, sasia 150 ml/ha, dhe Furore Super, 800 ml/ha, On date: 17.04.2019
First treatment with fungicide	Falcon, 500 ml/ha, on date 16.04.2019

The second re-fertilization	NAG 27%, 200 kg/ha, on date 08.05.2019
Second treatment with fungicid	Falcon, 500 ml/ha, on date 25.04.2019
Harvesting of wheat plots	16.07.2019

All agro-technical measures applied during the wheat cultivation period, for the vegetation of 2019/2020 in the two localities (Dukagjini Plain and Kosovo Plain), are presented as follows:

Table 3. Applied agro-technical measures in Dukagjini Plain during the year 2020

AGROTECHNICAL MEASURE	Location- Dukagjini plain/ Peja
Previous crop:	Potato and maize
Plough	14-15.10.2019
Fertiliser	NPK 16:16:16, 400kg/ha, 17.10.2019
Power harrow, Roll after drilling measuring and dividing fields.	17.10.2019
Sowing	21.10.2019
The first re-fertilization	Urea 46% N, 200 kg/ha, on date 18.02.2019
First treatment: with insecticide a fungicide	Lamdex ^{R} 50 SC, , sasia 200 ml/ha, and fungicide Falcon EC 4 500 ml/ha, on date 08.04.2020
Second treatment: with herbicid	Secator OD, 150 ml/ha, and Furore Super, 800 ml/ha, 12.04.2019
The second re-fertilization	NAG 27% 200 kg/ha 19.04.2019
Harvesting of wheat plots	10.07.2019

Table 4. Applied agro-technical measures in Kosovo Plain during the year 2020

AGROTECHNICAL MEASURES	Location- Kosovo plain/ Lipjan
Previous crop:	Maize
Plough	16.10.2019
Fertiliser	NPK 16:16:16, 400kg/ha, on date 22.10.2018
Power harrow, Roll after drilling measuring and dividing fields.	22.10.2019
Sowing	23.10.2019

The first re-fertilization	Urea 46% N, sasia 200 kg/ha (data: 19.02.2020)
First treatment: with herbicide	Secator OD, sasia 150 ml/ha, and Furore Super, 800 ml/ha, on date 15.04.2020
Second treatment: with fungicide	Falcon, sasia 500 ml/ha, on date 19.04.2020
The second re-fertilization	NAG 27% 200 kg/ha, on date 24.04.2020
Harvesting of wheat plots	15.07.2020

9.3 Appendix (3) Supporting scheme of Kosovo for renewable energy and its fiscal policies

Table 1. Supporting scheme of Kosovo

R.E.S. support schemes 2018-2019	Per unit support
Feed-in Tariffs (Euro/M.W.)	HPP **(<10MW)** 67.47, Wind 85.0, Solid biomass 71.3, Photovoltaic 136.4.
Feed-in premiums	
P.P.A. old state hydropower (price premium in 2018/2019 = purchase price - K.E.K. purchase price)	€ 3.44/7.8/MWh (1-10 M.W.) € 7.68/8.3/MWh (>10 M.W.)
Investment subsidies (capital grants or loans) (€/unit)	50-60% grant on investment in small R.E.S. in agricultural farms € 1,080/kW (estimated)

Source: (M.E.E. 2021)

Table 2 Overview of fiscal policies and measures from governmental and non-governmental level

Name and reference of the measure	Type of measure	Expected result	Existing or planned
a) Financial support	Formation of clusters for increased use of biomass (pellets) and solar	Formation of clusters dealing with all aspects of producing pellets and deployment of the project with solar energy	Existing 2014
b) Financial support	Agriculture and Rural Development Program Grant support scheme for farmers	Sustainability of the sector and work jointly to increase production, establish new processing lines and upgrade farm machinery and equipment, as well as work conditions at the farm level	Existing 2014

c)Financial support non-governmental	Women Entrepreneurs	Support women in making necessary investments in energy efficiency measures and modern equipment that will help them grow their business and use green energy	Existing 2020
d) Financial non-governmental	Customs exemption for components and equipment for R.E.S. use	Increased cost-benefit of R.E.S. projects, attracting investment	Existing 2017
d) Financial non-governmental	V.A.T. exemptions for investments in R.E.S.	Increased cost-benefit of R.E.S. projects, attracting investment	Existing 2017
e)Financial support	Green Economy Financing Facility	S.M.E. companies, households	Existing 2018

Source: (M.E.E. 2021); Targeted group and activity a) Producers of pellets, wood equipment producers, installers of solar panel and P.V. system; b) Farmers; c) Women Energy Entrepreneurs d) Investors; e) Increase of R.E.S. capacity with private consumers, S.M.E. companies.

9.4 Appendix (4) Questionnaire- Farmers' Attitude Towards Straw Biomass Selling for Bioenergy Purposes

To know how the farmers themselves see their situation and the trade-offs they make willingly or unwillingly with regard to residue generation and use, we constructed the questionnaire below.

1. Farm Location

2. Farm size

3. Crops grown________ ha ________ ha________ ha

4. Education level of household head

1. Lower than elementary
2. Elementary school
3. Agricultural high school
4. Other secondary school
5. University

5. Annual incomes _______€

5.1 From agriculture______%

6. Fulltime or part time farmer

7. Age of household head______

8. Total years actively farming___________

1. The amounts of residues used for various purposes (in percentage)

1.____________

2.____________

3._____________

11. If you do not currently bale some/all of your straw, tick all applicable reasons for not doing so for the relevant crop(s)?

Lack of a market
Lack of machinery
Timeliness of operations (i.e. Delays in establishment of the next crop)
Perceived benefits of incorporation (e.g. soil structure/ nutrients)
Concerns about using contractors or selling in swath
Concerns about soil compaction
Other (please state)
Other (please state)
Other (please state)

	Wheat	Corn

12. What single factor would most encourage you to bale straw?

If other please state
1. Lower fertilizer prices
2. Fixed minimum price for straw
3. Guaranteed price
4. Good price
5. Hearing the benefits from other farmers
6. Long term soil benefits
7. Guaranteed market
8. None
9. Other

13. What is the lowest price you would be willing to sell your baled wheat straw for? (€/t) This is the selling price for big bales sold off the field/ at farm gate assuming typical harvest and current costs

30	40	50	60	70	80	90	100	110	120	130	140	150	160

14. If there was a market for using straw in a bio-energy power plant what percentage of your straw would you be willing to sell if the price was acceptable to you?

Wheat	Barely	Corn

15. What is the number of consecutive years you would supply cereal straw for?

1	2	3	4	5	6	7	8	9	10	11	12	13	14	+15

16. Which type of contract volumes would you be willing to supply straw to a biomass power plant (tick all appropriate)

Supplying fixed tonnage of straw	
Supplying minimum tonnage of straw	
Supplying fixed area of straw	
Supplying minimum area of straw	
Supplying a percentage of your straw	
Supply over and above agreed contract amount	
Supplied amount dependent of farm surplus	
None of the above	

17. Which types of straw prices would you prefer in a contract to supply a biomass power plant (tick all appropriate)

Fixed price	
Minimum price with actual price based on market forces	
Spot market price	
Price linked to the price of oil	
Fixed price for contracted tonnage with spot market price for supply beyond this	
Higher price for longer term contracted supply	
Price linked to prices of P and K fertilizers	

18. What is the maximum length of contract you would find acceptable (if contract agreements were acceptable to you)? (years)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	+15

19. What practices do you apply for crop rotation

____

20. Do you use any alternative sources of energy, if yes which one?

____

20.1 Annual expenses for current alternative sources____________€

22. The amount (m^3) of wood consumed for heating purposes per year___________

23. Household size__________.

24. Where do you get the wood (in percentage): a) From your own land_______ b) Buy_____ price per m^3_____ c) Illegal__

9.5 Appendix (5) Questionnaire for income determinants of farm households

1. Farm Location

2. Farm size

3. Crops grown________ ha ________ ha________ ha,

3.1 Selling price per kg _____, _______,______,_______

3,2 The amount of kg produced per each culture ______, __________,_________,_________

4. The education level of household head (%)

1. Lower than elementary
2. Elementary school
3. Agricultural high school
4. Other secondary schools

5. University

5. Annual incomes _______€

Income shares (%)
- Farm income______
- Nonfarm income______
- Unearned income_____

6. Engaged in agriculture
   1. Full-time
   2. Part-time farmer

7. Age of household head______

8. Total years actively farming_______

9. Household size________

10. Children under 18______

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Since the first day of my school, I knew that the last one would be far away and that I had to finish it. Today, I am proud that after experiencing many struggling situations in my country like war (1998-99) and the last one, coronavirus, I fulfilled the objective of this little child which was me.

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