ENERGY SELF-SUFFICIENCY OF FARMS IN KOSOVO: AN APPLICATION OF SWOT AND PEST METHODOLOGY

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Abstract

Energy stands as a vital stimulus for societal, economic, and technological progress globally. Energy self-sufficiency has emerged as a strategic goal for many nations, driven by concerns over energy security, sustainability, and economic resilience. Within this context, Kosovo relies heavily on fossil fuels and insufficient alternative energy sources, making it tough to achieve self-sufficiency in agriculture. The agricultural domain relies extensively on energy to power various of its operations, rendering energy self-sufficiency a compelling avenue for addressing associated challenges.

By serving as a benchmark that evaluates the current status and charts a prospective roadmap for fostering the renewable energy sector in Kosovo, the SWOT analysis delineates internal strengths and weaknesses alongside external opportunities and threats. Emphatically, the study highlights the indispensability of public awareness campaigns, capacity-building initiatives, and streamlined access to financial resources. Additionally, the study emphasizes the pivotal role of project preparation, credit accessibility, financing costs, and equity financing facilitation in bolstering the nation's prospects for realizing its energy self-sufficiency objectives, otherwise Kosovo may struggle to meet its energy goals.

Keywords: *efficiency, RES, agriculture, attitude*

JEL: *O13, Q15, Q16, Q42*

Introduction

The main causes of the rising global energy demand, which is currently based on fossil fuels and prevents sustainability over the long run, are the world's population expansion and economic and social progress. The consequences of environmental degradation, encompassing the impacts of global warming, necessitate alterations to the energy supply. Since fossil fuels are the primary source of energy worldwide, the usage of electricity has a significant impact on greenhouse gas (GHG) emissions. The largest and most popular renewable energy source in the world, biomass is seeing a steady increase in utilization (Popp et al. 2013) (Bilandzija et al. 2018) (Sertolli et al. 2022). A variety of non-renewable and renewable energy sources power the agriculture sector. As per the Food and Agriculture Organization (FAO), the agri-food chain systems presently account for thirty percent of the global energy production, whereby the transportation, processing, packing, shipping, storage, and marketing sectors require approximately seventy percent of the energy (FAO & IRENA, 2021). Fossil fuel use in agriculture is linked to significant negative environmental effects. Eliminating reliance on fossil fuels for energy security is essential to achieving the objective of implementing energy-smart food systems, since it enables the production of more food using renewable energy sources. Green energy has the ability to lower pollution while simultaneously meeting the energy needs of the production sectors. Improved energy use, food security, and environmental change are outcomes of using renewable energy sources for agricultural chores, which aligns with the goals of ecological agriculture. The dominant source of energy in Kosovo is lignite, both national and agricultural level, which is available locally and the cheapest fuel. However, renewable

energy sources have long drawn significant attention in Kosovo, particularly from the ministry of economy, as a fossil fuel substitute. The nation has determined that developing renewable energy will increase national energy security while simultaneously lessening the negative effects of using fossil fuels.

Literature review

Agriculture and energy self sufficiency

It is obvious that the burning of fossil fuels releases greenhouse gases (GHGs), such as CO2, CO, and CH4, among others, which cause climate change. In the European Union (EU), a variety of interconnected policies and tools are helping to solidify the shift to a low-carbon economy. The EU is committed to using secure, safe, competitive, locally produced, and sustainable energy and to transitioning to a low-energy economy in light of mounting evidence of climate change and growing energy dependence (Bujdoso et al, 2012, Gabnai, 2021).

Due to its high energy consumption, the agriculture sector was accountable for 9.3 billion tons of worldwide CO2 equivalent (CO2eq) emissions in 2018 (FAO, 2018). Arable farms offer access to a variety of recyclable, locally produced resources for energy generation in the form of production wastes. These leftover materials can already be utilized to produce power, heat, and gasoline for automobiles. Over the past few years, there has been a tremendous advancement in the technical development of biomass-based energy generation systems. As a result, there are now more small-scale applications that are suited for use on farms, and straw is now frequently used as a fuel for farm heating. In 2020, the European Union had 9.1 million agricultural holdings (Eurostat, 2022). Families farm, which are farms where at least 50% of the regular agricultural labor force is provided by family members, account for the vast majority of farms in the European Union (94.8 percent in 2020). Less than five hectares (ha) accounted for over two thirds of all EU farms in 2020, as can be seen in the Figure 1. With their potential to provide food and additional revenue, these small farms can significantly lower the likelihood of rural poverty. On the other hand of the productivity spectrum, 7.5% of farms in the EU were 50 hectares or larger.

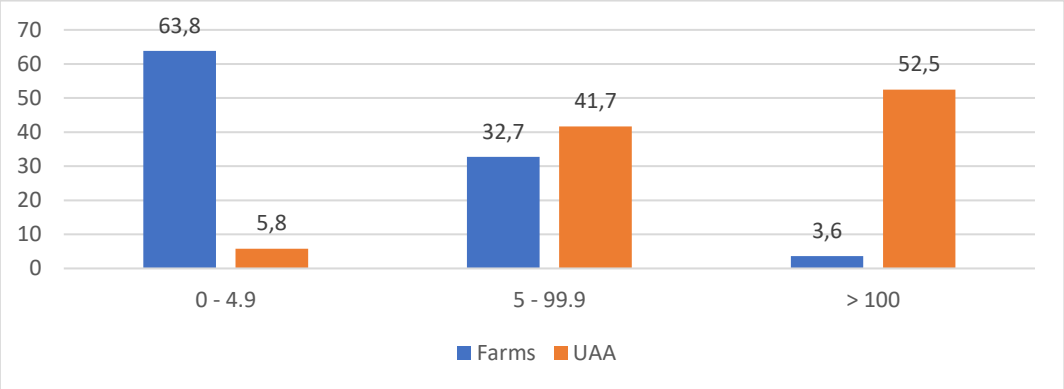

Figure 1. Distribution of EU farms and utilized agricultural area (UAA) according to farm size 2020

Source: Author's own construction based (Eurostat, 2022) data

Larger agricultural holdings, which are classified as 50 hectares or larger, were found to be more common in several of European nations. In particular, significant percentages of these larger farms were found in Luxembourg, France, Finland, Germany, and Denmark; these countries accounted for 52.7%, 46.0%, 33.3%, 31.5%, and 30.9% of all farms, compared to the total numbers of farms at national levels, respectively. Furthermore, in the majority of Member States, these larger-scale agricultural operations—which are defined by a minimum size criterion of 50 hectares—accounted for the majority of Utilized Agricultural Area (UAA).

According to the statistics of the European Commission, the average size of the farm is 17.4 ha, however, this is not a typical average, due to the fact that in Europe you can find so many farms with a size lower than five hectares and more than 100 ha. It is possible to classify nearly six out of ten farms in the EU (58.3%) as crop specialist farms (Eurostat, 2022). Moreover, organic waste of these farms can be converted into biogas, which can be used in gas engines to produce combined heat and power (CHP), or it can be upgraded to vehicle fuel quality and used in tractors. In this regard, specialized livestock farms made up another one-fifth (21.6%) of all farms in the EU; the most common types of these farms were specialized dairy farms (5.1%) and specialist farms that raised and fattened cattle (4.2%). However, since biomass is a finite resource and requires energy for growth, harvesting, and conversion into usable energy carriers, producing biomass-based energy carriers may have ramifications. Additionally, biomass is a bulky material, which restricts the economically viable transport distance. If the biomass is solely utilized on the farm of origin and only the residual (non-edible) products are employed as energy sources, these consequences can be avoided.

According to the 2014-year article of Popp et al, by the year 2050, an estimated 1500 EJ of biomass are available globally, of which 200–500 EJ might be sustainably used to meet 40–50% of the projected primary energy demand (Popp et al. 2014). In overall, the EU's principal supply of solid biomass increased by 33.5% from 3.3 EJ in 2008 to 4.5 EJ in 2021 (European Commission, 2023a). Mostly biomass from woods or forests (66%), followed by biomass from organic waste (26%), of which three-quarters came from Germany, and agricultural biomass (8%), primarily from Sweden and Finland. During this time, the usage of wood pellets (413%) and animal waste (351.9%) resulted in the largest increases in domestic production of solid biomass.

In 2022, the EU attained a 23% of its gross final energy consumption from renewable sources. Sweden led the EU with over two-thirds (66.0%) of its gross final energy consumption coming from renewable sources in 2022 (Eurostat, 2023c). According to the (Paris et al. 2022) analysis, open-field agriculture in the EU uses at least 1431 PJ of energy annually, or roughly 3.7% of the EU's total annual energy consumption, hence, the majority of crops require energy inputs ranging from 15 to 25 GJ/ha, mainly of the energy comes from non-renewable sources. The principal uses of this energy are in the production of fertilizers diesel use, production of pesticides and seeds and so on. In terms of solar PV (photovoltaics) the energy production in 2021 was 159 TWh for European Union (IRENA, 2023). Worldwide, 92 TWh of energy production came from biogas in 2021.

Renewable energy in Kosovo and its self-sufficiency especially in agriculture

Increasing Kosovo's energy mix's proportion of renewables is essential to the country's green recovery. In Kosovo, 94.95% of electricity generated in 2019 came from coal, with only 5.05% coming from renewable sources (OECD, 2024). Hydropower generates 67.7% of the electricity generated under the renewable share, whilst wind power contributes 28.9% and solar energy just 3.4%.

With renewables accounting for 25.69% of total final energy consumption in 2019, mainly for heating purposes, the lower objective had been met. Table 1 shows a comparative table between the EU, Kosovo, and some other countries in terms of renewable energy share, gross electricity consumption, heating and cooling, and transportation. As can be seen, Scandinavian countries led the table with the highest level of renewable energy development, followed by central European countries, and Balkan countries.

Table 1. Share of renewable energy in European and Balkan countries

Countries	Share of energy from renewable sources	Share of energy from renewable sources in gross electricity consumption	Share of energy from renewable sources in heating and cooling	Share of energy from renewable sources in transport
EU	23	41	25	10
Kosovo	19	7	47	0
Norway	76	120	34	24
Sweden	66	83	69	29
Denmark	42	77	50	10
Austria	34	75	36	10
Germany	21	48	17	10
Croatia	29	56	37	2
Hungary	15	15	20	8
Albania	44	103	22	0.4
Montenegro	40	63	65	0.3
Macedonia	19	24	37	0

Source: (Eurostat, 2023b)

The efficiency in the energy system of Kosovo will be achieved when the economy becomes less energy-intensive by following a more energy-efficient development path. This has a number of advantages, such as lowering the need for energy supplies, which in turn reduces the need for expensive expenditures and the associated greenhouse gas emissions and pollution, reducing reliance on imports, and lessening the financial burden on individuals and companies. Two specific objectives approach this strategic objective: increasing building energy efficiency and the encouragement of effective district heating systems and cogeneration (ME, 2022).

In Kosovo, the proportion of renewable energy sources has somewhat increased in recent years. The Ministerial Council of the Energy Community established the national RES objective for Kosovo in 2012, and the Ministry of Economy subsequently adopted secondary legislation to ratify it. Kosovo exceeded its objective of 25% RES (renewable energy sources) share in 2020. Biomass contributes around half of the energy needed in the heating sector. For a number of reasons, the proportion of renewable energy sources in transport is negligible. Firstly, the legal framework does not include regulations pertaining to the sustainability of biofuels, which means that Directive 2009/28/EC and Directive 2018/2001 are not followed. Households account for the greatest portion of the final energy use, comprising 40% of the overall use in 2020. Transport is the second-largest energy-consuming sector, with energy consumption rising by almost 100 ktoe to 422 ktoe (ME, 2022).

Kosovo's energy efficiency industry faces numerous obstacles. One of the difficulties is that there aren't enough competent people, especially in the public sector, to oversee the execution of projects. According to (Pestisha–Bai, 2023) people are open to installing renewable energy equipment but they mentioned that high costs of purchase are one of the main disadvantages and the lack of support from the state.

The natural environment of Kosovo is both incredibly complex and conducive to the diversified growth of agriculture. Small-scale family households are the main source of production in Kosovo due to the current natural environment and property arrangements. Kosovo is split into seven distinct areas, each with the neighboring municipality, based on shared characteristics like as climate, agricultural production structure, arable land, size of the yields, cattle and crop density, etc. The distribution of agricultural holdings by production type is primarily influenced by both structural and environmental factors. It may be emphasized that a significant portion of the nation has conditions that are mostly favorable for raising livestock and crops, moreover, combining the production of livestock and crops, taking into account the structure of the agricultural land and the surrounding environment. With a total size of 10,905 km2 and 512,000 ha of arable land, the Republic of Kosovo is located in southeast Europe. The total arable land per capita in 2019 was 0.11 hectares, while the average total utilized agricultural area per capita was 0.24 hectares, according to the Green Report (MAFRD, 2020).

The Kosovo economy's strategic sector of agriculture accounted for 7.4 % of GDP in 2022, making it a vital economic force (MAFRD, 2023). The majority of farms in Kosovo are medium-sized tiny farms, with an area of less than 5 ha, while the situation in the European Union is a little bit different with approximately two-thirds of the farms being less than 5 hectares (ha) in size in 2020 (Eurostat, 2022). This is a significant issue that contributes to low productivity and rising production costs in Kosovo. In 2021, 420,327 hectares of agricultural land were under use. The categories of use break down into the following: arable land, which includes fields, gardens, 0.3%, tree plantations, 2.4%, vineyards, 0.8%, meadows and pastures (including common land), and 51.7% for fields, including vegetables in the open and in greenhouses. A total of 108,803 agricultural properties were included in the Agricultural properties survey according Table 2. Approximately 64 % of the agricultural properties were up to five hectares, with an average size of 1.7 hectares (MAFRD, 2017).

Table 2. Size of holdings by surface of arable land and number of holdings

Farm size	Surface (ha)	%	No. of Agricultural holdings	%
0>5	118537	64	102530	94.2
5>10	29498	16	4531	4.2
10>20	16258	9	1253	1.2
20>30	5300	3	226	0.2
30<	16109	9	263	0.2
Total	185702	100	108803	1

Source: (MAFRD, 2017)

The most recent agricultural census in Kosovo was conducted in 2014, rendering the data somewhat dated. Nevertheless, given the stability of agricultural practices and conditions in the region, it is reasonable to anticipate that current figures would approximate those of the preceding census, with a marginal increase. Table data are nearly the same in the Western Balkan regions that are

characterized by small-scale agriculture, such as 1.2 hectares in Albania (European Commission, 2024), 1.9 hectares in Macedonia (FAO, 2023), and 4.6 hectares in Montenegro (MONSTAT, 2017).

With 345,329 t/year of biomass produced from cereal residues and 30% of that capacity allocated for energy needs, Kosovo has an annual energy potential of 103,599 t/year in terms of total biomass capacity utilized for energy purposes (Sertolli et al. 2023). The main importance of this potential is that by-products can be used locally (unlike main products), due to their low value which cannot make possible their long-distance transportation. By-products generated from agricultural activities, including crop residues and animal manure, offer a renewable and readily available source of biomass for energy production. Through various conversion technologies such as anaerobic digestion, biomass combustion, and biofuel production, agricultural by-products can be transformed into heat, electricity, biogas, and biofuels, thereby reducing reliance on fossil fuels and mitigating greenhouse gas emissions. Furthermore, the utilization of agricultural by-products for energy generation promotes circular economy principles by closing nutrient loops, reducing waste, and enhancing resource efficiency. The potential of wastewater treatment to exploit the potential of circular bioremediation in the Indian context was analyzed by (Singh et al. 2023). Measuring the level of efficiency is complicated; it needs a specific methodology and database, that is suitable for the calculation of different levels of efficiency indicators (partial, complex, social, corporate, etc.) (Nábrádi et al. 2009).

In terms of livestock, cattle, sheep, goats, and poultry account for 98% of the livestock production in the country, as mentioned in Table 3.

Table 3. Livestock by unit in livestock structure of Kosovo, 2023

Livestock	Thousand LSU (Livestock Unit)	Share (%)
Cattle	213	72
Sheep and goats	24	8
Pigs	23	8
Poultry	37	12
Total	297	100

Source: (MAFRD, 2023)

Table 3 shows that the livestock in Kosovo are a great source of waste (manure) produced by them, and a part of them can be used for another source of renewable energy, biogas. According to the study of (Sertolli et al. 2023) 3,84 million t/year is the total potential for animal manure production in Kosovo, from which 76.4% or 142.6 million m3/year of can be used for the production of biogas, whereas the other part for organic fertilizers, with cattle contributing the most in this regard. Moreover, a systematic review published by (Pestisha et al. 2023) showed that due to its sustainability and environmental friendliness, biogas has been the most searched on-farm renewable energy source between 1988 and 2022, with more interest source in farms.

However, considering the current state of sustainable agriculture energy use, and the self-sufficiency of farms in Kosovo is necessary given the evolving nature of both European and global energy policies for agricultural production as well as the fact that sustainability has become a crucial issue, gaining more urgency with climate change and scarcity of natural resources. In light of this,

it is crucial to analyze the variables impacting farms' propensity to engage in energy-sufficient activities. This study investigates the several elements that influence farmers' agricultural activities and their openness to investigating novel energy sources for their farms.

SWOT studies towards sustainable energy sources in other countries

(Chen et al. 2014) elaborated the SWOT analysis for Japan, Taiwan, and South Korea, and based on the literature reviewed in this study, several conclusions and areas of ambiguity emerge. The author posits that the above-mentioned countries' historical reluctance to fully embrace renewable energy stems from entrenched pro-nuclear energy policies that hindered advancements in alternative energy sources. However, following the Fukushima nuclear disaster, there has been a notable shift towards greater support for renewable energy initiatives in these nations. The author underscores the imperative for collaborative efforts among these countries to drive policy reforms and technological innovations conducive to the proliferation of the green energy sector.

The assessment of Ghana's nuclear power program is conducted through a SWOT analysis of (Agyekum et al. 2019). Despite concerted efforts by the nation to adhere to licensing, contracting, construction, and operational standards for nuclear facilities, several significant gaps remain that could potentially lead to delays in the implementation process. The analysis reveals that Ghana presents a multitude of advantages that render investment in nuclear power a financially prudent decision. However, challenges impeding the seamless deployment and operation of a nuclear power plant include vulnerabilities in security systems, instances of corruption, porosity of borders, and policy discontinuity arising from fluctuations in political leadership. Furthermore, the authors identified financing as a particular weakness and outlined potential funding mechanisms to address this constraint.

Moreover, a SWOT analysis was conducted for Iceland, Sweden, China, India, and the United States (Elavarasan et al. 2020). This study reveals that China and India should enhance the efficiency of coal utilization, achieved through the adoption of advanced technologies and the utilization of higher-grade coal varieties characterized by lower emissions. Additionally, increasing reliance on renewable energy sources is recommended, requiring measures such as market liberalization, institutional innovation, and subsidies aimed at incentivizing the adoption of green energy alternatives. Conversely, Sweden and Iceland are encouraged to allocate greater investments towards hybrid renewable energy systems (HRES) to optimize energy capture and utilization efficiency. Such systems integrate multiple renewable energy sources, offering enhanced reliability and resilience in energy supply while minimizing environmental impacts.

While in terms of the USA, recognized as one of the largest energy consumers globally, there exists a pressing imperative for the nation to significantly reduce its carbon emissions. Consequently, the United States has embarked on a trajectory to diversify its energy portfolio by exploring alternative renewable energy sources. This strategic shift is underscored by a confluence of factors, including the imperative to mitigate climate change, regulatory frameworks incentivizing renewable energy adoption, and public subsidies directed toward fostering sustainable energy solutions.

Furthermore (Kamran et al. 2019) analyzed the SWOT of Pakistan's renewable energy towards sustainability. The research underscores that the strategic policy framework for renewable energy (RE) should prioritize four key objectives: enhancing energy security, fostering economic prosperity, promoting social equity, and safeguarding environmental integrity. To facilitate the expansion of renewable energy infrastructure, particularly in addressing challenges related to land acquisition

costs and grid expansion, government intervention could be directed toward supporting decentralized biomass power plants and incentivizing rooftop solar installations. Moreover, policy measures aimed at advancing renewable energy deployment should be complemented by initiatives aimed at discouraging reliance on imported oil and coal for electricity generation, thereby fostering diversification of the country's energy mix and reducing dependency on non-renewable resources.

In terms of Jordan, (Jaber et al. 2015) determined the country's SWOT indicators. The study posits the challenge of identifying commercial banks in Jordan that provide specialized financing arrangements with reduced service fees tailored to support Renewable Energy (RE) and Energy Efficiency (EE) projects. Additionally, it underscores the imperative for the government to formulate a comprehensive long-term strategy about the unit costs associated with electricity generation from renewable energy sources. This strategic imperative is crucial for facilitating the proliferation of RE and EE initiatives, ensuring their sustainability, and fostering a conducive environment for their successful implementation within the Jordanian context.

This study's main goal is to investigate the current state of renewable energy in Kosovo, as well as its potential, obstacles, and energy self-sufficiency in Kosovo farms, rather than to provide definitive information about its application in agriculture.

Material and method

To the best of the authors' knowledge, there is a study gap on energy self-sufficiency from biomass sources; thus, a SWOT and PEST analysis is carried out to gather additional information. For this study, an exploratory research methodology was used. Furthermore, the authors have discovered a dearth of studies aimed at pinpointing the main drawbacks and risks associated with using integrated biomass for energy consumption in conjunction with an agricultural strategy. In addition to creating a SWOT analysis in this context, the primary research topics this study attempts to address are as follows:

- What obstacles exist for Kosovo's farms when it comes to using biomass for energy?
- What are the benefits, drawbacks, risks, and chances associated with energy self-sufficiency in farms as a novel strategy?

To access the internal and external elements related to the development of renewable energy and its influence on Kosovo, a SWOT framework approach analysis is employed. This will help to clarify Kosovo's sustainability problems and offer recommendations for the most effective ways to have a bigger influence and spur more growth. It can be used to decide on the best direction for your endeavor, find areas where change is conceivable, investigate the potential for new endeavors or problems to solve and assist in modifying and improving plans as needed. In the context of Kosovo's development of renewable energy, the combination of three approaches used in this study—which has not been done in prior research—will help to identify what is working well, develop a better strategy for improvement, and have a greater effect on socioeconomic development. This is due to the widespread conviction that the problems confronting the energy sector today can be resolved, and that implementing renewable energy with an emphasis on rural areas will significantly contribute to Kosovo's energy problem resolution and sustainable national development. Over the years, several academics have employed the SWOT approach to ascertain the sector's possibilities and threats from the external environment as well as its internal environment's

strengths and weaknesses. According to (Chen et al. 2014) SWOT framework is typically made up of both external and internal evaluations. An organization's or a strategic plan's strengths and weaknesses are illustrated through internal assessments, while opportunities and dangers are found through external assessments. Originally developed for business and marketing analysis, the SWOT paradigm has found widespread application in a variety of different study domains, including energy management. In regard to SWOT analysis, an enhanced understanding of the likelihood of success and failure is attained via the examination and evaluation of internal and external factors impacting performance (Jaber et al. 2015) (David et al. 2021) (Bittner et al. 2018). It is simple to convert this vision into goals and actions that will help accomplish the following issues: identify and address areas of weakness, build upon areas of opportunity, strengthen or maintain areas of strength, and get ready for areas of threat.

The SWOT analysis in the current study (Table 4) is attained through secondary sources such as different studies and research papers, reports of the Ministry of Agriculture, Forestry and Rural Development, institutional reports, and statistics.

Table 4. SWOT analysis for renewable energy in Kosovo

Strengths	Weaknesses
Geographic location (ME, 2024)	Insufficient technical expertise in various RES technologies (MAFRD, 2022)
Ambitious targets to increase the share of renewables (ME, 2022)	Initial and installation costs (Zhang–Xu, 2020) (Elavarasan et al, 2020)
The legal framework is developed (ME, 2022)	Lack of public financing resources (European Commission, 2014)
	Land fragmentation (MAFRD, 2014)
	Insufficient collateral to qualify for small-project lending schemes (MAFRD, 2022)
Opportunities	**Threats**
Availability of resources that guarantee a continuous supply of heating and other energy forms (Sertolli et al. 2023)	Inadequate level of knowledge and expertise regarding RE technologies (Szakály et al. 2021)
Energy and climate change (ME, 2022)	Insufficient local financial schemes for RES projects (MAFRD, 2022)
Reduction of the farm energy expenses (Bathaei–Štreimikienė, 2023)	
Environmental eco-friendliness (Rath et al. 2021) (Botelho et al. 2016)	RES systems with energy storage can be costly (IRENA, 2017)

Source: Author's own construction

In addition, four categories of external environmental factors are examined by PEST analysis, which are as follows:

Political factors (P): these encompass a range of government actions and political advocacy inside an economy. Economic factors (E): these mostly deal with the external environment's macroeconomic circumstances, though they can also take seasonal and meteorological factors into account. Social elements (S): these comprise external environment social, cultural, and demographic

aspects. Technological infrastructures, technological incentives, technological activities, and technological advancements that impact the surrounding environment are all considered technical aspects (T). These factors can be found evaluated below in regard to the study topic.

Table 5. PEST analysis for renewable energy in Kosovo

Category	Code	Factor
Political	P1	New strategy oriented to renewable energy
	P2	Initiative to embrace renewable energy through the grant policy
	P3	Feed in tariffs (their impact as incentives)
	P4	Promoting energy efficiency through subsidies
Economical	E1	Improving rural and farmers' incomes
	E2	Making the energy sector more stabilized
	E3	Stable energy prices and elimination of energy shortages
Social	S1	Public awareness and perception
	S2	Energy sectors create jobs and foster talent development
	S3	Cooperation between farmers in sharing the best practices
Technological	T1	Applying the newest technology models
	T2	Taking the best practices in this regard from most developed countries
	T3	Automation, efficiency and self-sufficiency, technological tools

Source: Author's own construction

Results

Kosovo farmers face several challenges, including low farmer awareness of renewable energy sources, financial sources, high capital investments, inadequate farmer education, and a lack of government support. These findings are based on the factors identified by the SWOT technique used to determine energy self-sufficiency in agriculture. The ensuing paragraphs provide a more thorough explanation of each aspect.

S1. Geographic location

Kosovo's geographic location makes it an ideal place to implement renewable energy sources, particularly solar energy for both large- and small-scale solar photovoltaic development (ME, 2024). Furthermore, in terms of natural resources, Kosovo is the second richest nation in Europe and the fifth richest nation worldwide, especially considering its 12.5 billion tonnes of geological coal reserves or lignite (Sertolli et al. 2023). This makes lignite the most competitive product for renewable energy sources and the least expensive method of producing energy.

S2. Ambitious targets to increase the share of renewables

The overall goal set by the Energy Community for 2030 that is, reaching a 32% proportion of renewable energy in gross final energy consumption is consistent with the draft of the National Energy and Climate Plan of Kosovo (Energy Community, 2023). Sectional targets for electricity (45%), transportation (3,6%), and heating and cooling (49,6%) make up the overall 2030 target for renewable energy. Furthermore, by 2030, 261 ktoe of electricity is expected to be produced by renewable energy sources. Of these, wind energy will account for the largest proportion at 55%, followed by photovoltaics at 32% and hydropower at 12%. In terms of installed power generation capacity, renewable energy sources will account for 59% in 2030. According to projections of (Energy Community, 2023), the combined installed capacity of wind and PV will be approximately 1400 MW by 2030 (wind having 670 MW and PV having 730 MW).

With a 92% market share in 2030 and a steadily declining share to about 80% in 2040, biomass will continue to be the most popular renewable energy source in the heating and cooling industry. In terms of biofuels, they are not common in Kosovo, and it is anticipated that further regulations won't encourage the use of these fuels in the transportation industry. Nevertheless, it is anticipated that the transport sector's electricity consumption will rise significantly even though it will not meet the aim of 10% renewable energy by 2030.

Kosovo's electricity output is mostly dependent on two sizable thermal power facilities that burn lignite, namely Kosovo A and Kosovo B, but the coal's quality is quite poor, and the repercussions are severe (Pestisha–Bai, 2023). Furthermore, Kosovo's two primary lignite-fire power plants are extremely antiquated and seriously producing environmental issues and massive air pollution. Still, the nation has made a significant move in direction towards a wider variety of energy sources with the newly approved National Energy Strategy. Currently, the share of RES in electricity is only 6.3%, while biomass is dominating as the main heating source (ME, 2022). In addition to this, the goal of the state is to raise the proportion of renewable energy sources in power consumption to 35% by the year 2031, while limiting final energy usage to 1877 ktoe by 2031 is the overarching goal for energy efficiency.

S3. The legal framework is developed

Through the Ministry of Agriculture, Forestry, and Rural Development's annual Rural Development Programme, an extra support programme was created in 2014 to offer funds for RES applied in agricultural farms (ME, 2023). Farmers receive 50–60% of the overall investment costs back if RES is successfully implemented. With a total anticipated capacity of 4.19 MW21, 1,218 agricultural farms installed RES (mostly solar PV) between 2014 and 2021. The farms use all of the generated electricity. Furthermore, the legal foundation for the support systems for further renewable energy generation capacity was set many years ago. The Feed-in-Tariff Support Scheme, which is provided on a "first come, first serve" basis, is one way that the Rule on Support Scheme encourages investments in renewable energy sources; permits prospective investors to sell electricity based on a reference price established by ERO and to reach a PPA with the market operator; Market-based conditions such as the acquisition of the legal authorizations and permissions related to the environmental, technical, and social conditions, sell electricity to the market directly. For instance, years later, in 2020 ERO decided to end the Feed-in-Tariff subsidy programme for the creation of new RES capabilities (ME, 2023).

W1. Insufficient technical expertise in various RES technologies

Kosovo is deficient in capacity to manage complex projects in this field, as it is a new area and there is a lack of high-level experts. Training and knowledge transfer are desperately needed because of the persistent absence of investment in modern energy technology, which has stunted the growth of skilled farmers. The same is true for relevant awareness-raising campaigns that seek to change energy consumers' attitudes towards sustainable energy technologies, their behavior, and the standards used to make energy-related decisions. Among the issue of small farm structure, Kosovo's farmers are characterized by the lack of coordination among small farmers, inadequate education and training, a lack of technological know-how, hostile services, a lack of experience, restricted market access, and—above all—a lack of cooperation among farmers (MAFRD, 2022), which makes the integration of RES technology a problematic issue.

W2. Initial and installation costs

Kosovo gets the majority of its electricity from domestic low-quality lignite, a very polluting source. Numerous barriers are preventing Kosovo from transitioning from the generation of energy from power plants to renewable sources, such as the population's limited financial resources, which affect farmers as well. Farmers are not so motivated to install RES equipment on their farms because of the hefty expenses. This topic was further discussed in the article by (Pestisha–Bai, 2023), surveys conducted with farmers revealed that, although they would like to use these energy sources in their operations, the high prices of installation and purchasing prevent them from doing so. Additionally, they will take into account the advantages in this regard if the state provides them with grants or subsidies, to lower the farmers' expenses.

W3. Lack of public financing resources

The rate at which people may switch from fossil fuels to renewable energy may slow down in the absence of enough public investment. The advantages of cleaner energy, such as less greenhouse gas emissions and a smaller environmental effect, may take longer as a result. The development of renewable energy technology may be impeded by lower public support, which could result in increased consumer costs. Cost-cutting measures like economies of scale, research, and development are frequently made possible by public investment. In Kosovo, several renewable energy projects have been started, including wind farms and solar power plants but there are financial and infrastructural obstacles to the expansion of renewable energy (ME, 2022). Large sums of money are needed to develop new energy infrastructure, including grid upgrades and storage options. Although obstacles still exist, Kosovo has been attempting to strengthen its energy laws to encourage the growth of renewable energy.

W4. Land fragmentation

The agricultural sector in Kosovo is divided, with a significant number of small holdings and a limited number of major holdings. Serious structural issues are prevalent in Kosovo's agriculture. These consist of high production prices, inefficient labor, and fragmentation of land. Moreover,

extremely fragmented land affects the farming industry in Kosovo. Farms typically consist of six to eight (mainly very small) plots, according to (MAFRD, 2014). The degree of land fragmentation directly correlates with the efficiency of agricultural management and the rate at which agricultural machinery is utilized, both of which decrease the amount of land that is cultivated. For this reason, the application of RES in farms, especially agrivoltaics panels is hard due to the small size of and highly fragmented land.

W5. Insufficient collateral to qualify for small-project lending schemes

Agricultural loans will help the farmers to increase their activity in the advancement of renewable technologies and tools that will affect their productivity growth which will come from revenue growth and stability of the farm. Farmers incur significant costs when borrowing from banks and microfinance companies because agro-loans are referred to as non-performing loans (MAFRD, 2020). The absence of an insurance programme in agriculture has a major impact on farmers' ability to obtain loans, particularly low-cost loans. Due to the nature of the sector, it is thought to be extremely difficult to obtain financial support from banks in order to make investments in agriculture for the reasons listed above, in this case for RES investments as well. Borrowers who lack the necessary collateral may find it difficult to get the financing required to finance small-scale renewable energy projects. This may delay these projects' development and implementation, delaying the switch to greener energy sources.

O1. Availability of resources that guarantee a continuous supply of heating and other energy forms

Reliance on antiquated lignite-based electrical generation capacity, which offers poor flexibility and dependability and is a significant contributor to local pollution and greenhouse gas (GHG) emissions. At the moment, biomass-based energy sources constitute the main source of renewable energy in the energy sector, accounting for the majority of RES in the electrical sector at just 6.3%. While Kosovo's entire primary energy consumption in 2022 was 116 PJ, the total biomass potential, which can be used for energy purposes, can reach 33 PJ heating potential according to (Sertolli et al. 2023). Furthermore, it has the potential to account for 28% of Kosovo's overall energy consumption—a highly encouraging share. To provide a steady supply of energy, including heating sector, it is important to utilize a variety of energy sources, make investments in cutting-edge storage technologies, update infrastructure, and put energy-saving measures into place. The stability and dependability of the energy supply are further improved by community involvement, regional cooperation, and policy assistance. Kosovo and other areas can move toward a more robust and sustainable energy system by using these strategies.

O2. Energy and climate change

One of the main goals of the European agenda for attaining sustainability is the combination of energy and climate change. Driven primarily by worries about climate change, the EU Energy and Climate package sets 2030 goals to guarantee 40% of renewable energy sources in the EU's energy

mix and to cut greenhouse gas (GHG) emissions by 55% from 1990 levels (European Commission, 2023b). Kosovo is a new country in renewable energy activities, but it has exceeded its objective of 25% RES share in 2020 (ME, 2022). Nonetheless, because wood biomass is widely used as a heating source in Kosovo (Pestisha–Bai, 2023), there are large disparities in the sectoral RES shares and an uneven representation of the various RES technologies. In addition, by 2031, Kosovo wants to cut its power sector's greenhouse gas emissions by at least 32%, use renewable energy sources for at least 35% of its electricity consumption, and develop new RES capacity, including 600 MW of wind, 600 MW of solar PV, 20 MW of biomass, and at least 100 MW of prosumer capacity, to bring the total installed RES capacity to 1600 MW (ME, 2022).

O3. Reduction of the farm expenses

Farmers can generate their energy to become even more self-sufficient by lowering external inputs when combined with energy conservation methods. The agriculture and forestry sector in the European Union consumed 28.3 million tonnes of oil in 2021, which is the amount of energy directly used by this sector (Eurostat, 2023a). Renewable energy not only reduces costs for farmers, but also helps to mitigate the consequences of global warming. For ecological agriculture, the use of renewable energy sources for agricultural chores will lead to better food security, energy efficiency, and environmental change. Furthermore, the incorporation of renewable energy systems into agriculture can help rural communities become more resilient and self-sufficient, resulting in lower energy costs for them.

O4. Environmental eco-friendliness

Since burning coal and other fossil fuels to meet energy demands causes pollution and has negative consequences on both the environment and people, it is imperative that every industry use renewable energy sources. Because they are a major global energy source, fossil fuels are serious pollutants by producing greenhouse gases (NOX, SO2, and CO2). Hence, utilizing a variety of renewable energy sources is therefore the best option. Based on the article of (Pestisha–Bai, 2023), the respondents mentioned that eco-friendliness is more important for them when they purchase energy equipment. But it is crucial to handle possible negative effects on the environment, like resource extraction, waste management, and land usage, using technical innovation, careful planning, and mitigation techniques. Renewable energy can help create a more ecologically friendly and sustainable energy future by balancing these aspects.

TH1. Inadequate level of knowledge and expertise regarding RE technologies

As a result of no experience with renewable energy technologies, there is a step back regarding the expertise in this area. The inadequate level of training and seminars can impact the willingness to install any form of RES technologies in farms. The low level of RES promotion in this sector is just proof of the inadequate skills of farmers. Its threat can consist of putting farmers in a disadvantageous position in terms of competitiveness and farm diversification. This should be like an alert for policy makers and other stakeholders in order to promote this aspect and its importance.

TH2. Insufficient local financial schemes for RES projects

Commercial banks with special financing programmes that assist renewable energy projects with lower service charges are still rare in Kosovo. Last but not least, the ministry has implemented several funding programmes for the installation of renewable energy, particularly solar panels. This can encourage and assist farmers in incorporating renewable energy sources into their operations. These grant schemes would provide support at each stage of development, from demand for renewable energy and energy efficiency through public awareness, to early stages of project preparation, access to information, cost of financing, and access to equity financing. Additionally, it must focus its efforts on facilitating investors' access to simple financing options, such as soft loans.

TH3. RES systems with energy storage can be costly

Energy storage is one of the most challenging aspects taking into consideration that batteries have a high investment cost. Apart from that, energy storage lowers price volatility in the energy markets and enables more affordable integration of renewable energy sources. The deployment of energy storage is further complicated by financial and economic obstacles. The persistent unpredictability around renewable energy projects and the energy sector in general sometimes renders investments unappealing to farmers. In order to move towards a decarbonized and contemporary energy system, innovation and increased storage capacity are needed.

Whereas, in terms of PEST analysis, the situation in Kosovo is a combination of disputed political status and the willingness to achieve stability between different ethnic disparities. A crucial element in Kosovo's effective development of renewable energy is political stability. It promotes investor confidence, policy coherence, and efficient project execution in the energy sector. On the other hand, political unrest can cause turbulence and uncertainty that could impede the advancement of renewable energy. Kosovo may achieve higher sustainability and energy security by advancing its goals related to renewable energy and by executing solutions to overcome potential problems in a stable political environment. Stability in the social, technological, and economic spheres is essential to the development and implementation of renewable energy. Each component has a distinct role in guaranteeing the viability, efficiency, and sustainability of renewable energy initiatives. Kosovo is determined to accomplish the consolidation of these facets to enhance this industry.

Discussion

Through an examination of the Strengths/Weaknesses and Opportunities/Threats (SWOT) framework, a strategic portfolio of actions emerges, delineating endeavors that leverage strengths and opportunities, alongside initiatives aimed at mitigating weaknesses or mitigating threats within the context of the national energy sector.

Numerous SWOT analyses have been employed as a methodological tool to delineate the advantages and drawbacks associated with the energy mix paradigm. For instance, (Chen et al. 2014) discerned that Japan, South Korea, and Taiwan boast abundant renewable energy reservoirs, further highlighting their potential for cultivating expertise in renewable energy technologies. This

assertion stems from their prominent status as major producers of cutting-edge technological goods such as motor vehicles, electronics, machine tools, semiconductors, and integrated circuit (IC) products. Conversely, (Jaber et al. 2015), in their SWOT analysis, underscored promising opportunities for the advancement of renewable energy initiatives in Jordan. However, they identified notable weaknesses, particularly concerning the scarcity of available financing mechanisms and uncertainties surrounding future electricity prices derived from renewable sources. Notably, the absence of dedicated financing programs from commercial banks, coupled with the unpredictability of Feed-in-Tariff mechanisms, emerged as significant impediments to renewable energy project development in Jordan (Jaber et al. 2015).

In a separate study, (Qaiser, 2021). utilized SWOT analysis to proffer strategic recommendations for bolstering sustainable energy endeavors in South Asia. These recommendations include the imperative establishment of robust transmission and distribution networks to interconnect potential renewable energy sites with the national grid. Additionally, the study advocates for the implementation of green financing initiatives featuring reduced interest rates and extended repayment durations to catalyze sectoral growth. Importantly, duty-free importation of renewable energy equipment and incentives to encourage self-generation of electricity are deemed essential to circumvent interruptions in municipal power supply.

Moreover, (Kamran et al. 2019)conducted a SWOT analysis specific to Pakistan's renewable energy sector, delineating both internal strengths and weaknesses. Noteworthy strengths include abundant renewable energy potential, validated resource mapping, environmental friendliness, and increasing private sector investment. Conversely, internal weaknesses encompass inefficient technologies, substantial capital requirements, an immature institutional framework, and environmental hazards associated with certain technologies, all of which necessitate remediation efforts for sectoral enhancement.

In Madagascar, a comprehensive SWOT analysis augmented by the application of a multi-criteria decision-making technique, namely the Analytic Hierarchy Process (AHP), was undertaken by (Yu et al. 2022). The findings underscore the salience of various factors within the SWOT framework. Main among them identified are: the deficiency in understanding pertaining to biomass briquettes, insufficient governmental backing, political volatility, societal receptivity towards biomass briquettes, a disproportionate emphasis on alternative renewable energy sources, and prevailing incentives favoring fossil fuels.

Similar to other developing nations, Kosovo is facing similar factors and effects, and in terms of bolstering the energy self-sufficiency of farms in Kosovo, it is imperative to adopt a multifaceted approach encompassing policy interventions, technological advancements, capacity-building initiatives, and stakeholder engagement strategies. Kosovo is endeavoring to cultivate its local RES market within the framework of its evolving economy. The primary challenges currently impeding the development of the local renewable energy market are encapsulated in the ensuing Table 4.

Table 6. Problems of renewable energy in Kosovo and actions to be taken

Problems	Actions
Poor support for RES initiatives from banks and finance	Establishment of bank financial schemes and state support (grants/subsidies)
Insufficient utilization of biomass in agriculture, industry, and stock breeding	Create supply chains for biomass.

Inadequate level of knowledge about RES technologies.	Training and seminars for interested people
Inadequate study and training programmes concerning RES sources and technologies, as well as a deficiency in practical research.	Mobilization of young researcher's support

Source: Author's own construction

In summary, in order to address the issues mentioned above, the authorized mechanism needs to be dedicated to a national energy plan that has specific goals for the use of renewable energy sources. The following are the most crucial areas:

- Elimination of current obstacles standing in the way of RES project implementation.
- Ability to develop and fortify public institutions for the implementation of RES
- Together with the interested parties, create a national RES master plan with a focus on involving rural communities as a fundamental component of the renewable energy initiative.
- To improve the local capacities of engineers, technicians, operators, and users of such systems, create training and awareness programmes on pertinent RES technologies.

Kosovo will continue to produce fossil fuels to fulfill its expanding energy needs, which might rise annually, unless local energy options, including renewable energy, are developed. The results of the SWOT analysis of Kosovo's use of RES indicate that there are promising chances that should be pursued further. To guarantee the effective use of RES systems, however, there are still significant vulnerabilities and dangers that need to be addressed. The availability of financing schemes and the potential future costs of power provided by renewable sources are two of the most significant limitations that could impede Kosovo's efforts to develop renewable energy sources. Commercial banks with dedicated funding programs to encourage RES growth are still rare in Kosovo.

Conclusions and recommendations

The Republic of Kosovo, similar to numerous other countries, confronts a plethora of challenges within the sphere of renewable energy development. These challenges are diverse and encompass technical, financial, regulatory, and socio-economic dimensions. Despite concerted efforts aimed at attracting investment, persistent financial barriers manifest in the form of limited access to funding and substantial upfront costs associated with renewable energy projects. Furthermore, the presence of uncertainty surrounding long-term returns on investment serves as a deterrent to potential investors. Additionally, Kosovo's energy sector exhibits a heavy reliance on fossil fuels, particularly lignite coal, for electricity generation. Effectuating a transition away from fossil fuels towards renewable energy sources necessitates meticulous strategic planning, technological innovations, and substantial investments in alternative energy infrastructure.

The imperative for capacity building and the cultivation of technical expertise in renewable energy technologies, project management, and maintenance is evident. By augmenting local skills and knowledge, the deployment and operation of renewable energy projects can be facilitated. Notably, the promotion of public awareness and acceptance of renewable energy assumes paramount im-

portance in cultivating a supportive milieu for its development. Educational campaigns and community engagement initiatives represent indispensable tools in combatting misconceptions and garnering public support for renewable energy endeavors.

Addressing these formidable challenges mandates a concerted endeavor from policymakers, industry stakeholders, and the populace to surmount barriers and realize the latent potential of renewable energy in Kosovo's energy transition. Collaborative initiatives, innovative solutions, and strategic planning constitute indispensable components in propelling forward the renewable energy agenda and attaining sustainable energy objectives in Kosovo. Cooperation and coordination between different stakeholders, such as governmental bodies, businesses, non-governmental organizations, and community groups, are required for collaborative ventures. This kind of cooperation makes it easier to combine resources, skills, and information, which improves the efficacy of initiatives and projects related to renewable energy. Undoubtedly, innovative solutions include technology transfer programmes, R&D projects, and implementing best practices from other areas or nations with comparable energy profiles. Meanwhile, strategic planning entails developing all-encompassing, forward-thinking plans that support Kosovo's long-term goals of attaining sustainable patterns of energy production and use. Setting precise and attainable goals and benchmarks, carrying out in-depth risk analyses and feasibility studies, and determining the most important areas for intervention and investment are all part of this process. Based on the SWOT analysis conducted on the utilization of RES in Kosovo's farms, it is evident that there exist promising opportunities and potentials warranting further development. Conversely, significant weaknesses and threats persist, necessitating remediation or mitigation measures to ensure the efficient utilization of RES systems.

Implementing energy efficiency measures on the demand side entails fostering structural transformations within the industrial sector, with a focus on promoting less energy-intensive industries. This may involve initiating energy efficiency programs alongside educational, training, and awareness-raising initiatives targeting residential, commercial, and public sectors. Furthermore, the integration of energy efficiency objectives within public policies pertaining to poverty alleviation, spatial planning, and fiscal frameworks is imperative for fostering a sustainable and efficient energy landscape.

Increasing agricultural and human resources capacities through the acquisition of knowledge pertaining to the management of RES technologies.

Implement a series of grant programs aimed at supporting farmers in the integration of renewable energy sources within their agricultural operations.

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