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National Energy and Climate Plan (NECP) of the Republic of Kosovo: The AFOLU sector

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Executive summary

All countries in the Western Balkans are contracting parties to the Energy Community and seek to join the EU. Therefore, they have committed to prepare National Energy and Climate Plans (NECP) that contain measures, activities, and goals as contributions to the EU's climate and energy goals. Here, we present a greenhouse gas emission inventory for the sector of Agriculture, Forestry, and Other Land Use (AFOLU) using the IPCC standard approach. For the baseline year of 2021, we find that AFOLU is a small sink of 50 Gg of CO_2eq., mainly because biomass regrowth in forests exceeds firewood withdrawal and overcompensates emissions from the agricultural sector. We projected the impacts of existing policies and measures until 2030. The projection results suggest a larger sink of 407 Gg of CO_2eq. With more ambitious additional policies and measures until 2030, the sink can be expanded to 1,045 Gg of CO_2eq. We conclude that AFOLU has great potential to contribute to the national emission reduction goals of Kosovo. We identify several low-hanging fruits that can achieve substantial emission reductions with comparatively low efforts, and we also discuss emission reduction strategies that can generate valuable co-benefits, such as for rural incomes, living conditions, and the environment.

Content

Abbreviations

AFOLU	Agriculture, Forestry, and Other Land Use
ARDP	Agriculture and Rural Development Program
BEF	Biomass expansion factor
CA	Conservation agriculture
CH_4	Methane
CO_2	Carbon dioxide
CO_2eq	Carbon dioxide equivalents
CORINE	Coordination of information on the environment
DBH	Diameter at breast height
EF	Emission factor
EnC	Energy Community
Gg	Gigagramme
GHG	Greenhouse gas
HNO_3	Nitric acid
IPARD	Instrument for pre-accession assistance for rural development
IPCC	Intergovernmental Panel on Climate Change
KAS	Kosovo Agency of Statistics
kg	Kilogrammes
LULUCF	Land Use, Land-Use Change, and Forestry
MAED	Model for Analysis of Energy Demand
MAFRD	Ministry of Agriculture and Rural Development
N	Nitrogen
n.a.	Not assessed
N_2O	Nitrous oxide
NECP	National Energy and Climate Plan
PaMs	Policies and measures
SARD	Strategy for Agriculture and Rural Development
UAA	Utilised agricultural area
VAT	Value-added tax
WAM	With additional policies and measures
WEM	With existing policies and measures
NH_4	Ammonium
NO_x	Nitrous oxide

1. Introduction

The National Energy and Climate Plan (NECP) is a planning and monitoring tool for the EU and its member states to ensure consistent reporting of greenhouse gas (GHG) emissions to the UN Framework Convention on Climate Change and the Paris agreement. It is a central instrument for achieving the EU 2030 emission reduction goals of between 50% and 55% compared to 1990. Each EU member state must prepare an NECP for the period 2021 to 2030 with additional longer-term projections up to 2050. Combined, the goals should ensure that the EU reaches its long-term goal of climate neutrality by 2050 to fulfil its commitment under the Paris Agreement.

The countries, which are part of the Energy Community (EnC), including all countries in the Western Balkans, are also required to prepare NECPs that contain a set of measures, activities, and targets, which outline the contributions of the countries to the EU climate and energy goals. Because the Western Balkan countries pursue joining the EU, they also need to achieve complete decarbonisation by 2050 (Regional Cooperation Council 2020). The NECPs of the Western Balkan countries should cover the period 2021 to 2030, include historical developments of GHG emissions, and outline both business as usual developments of GHG emissions with existing policies and measures (WEM), as well as a scenario with further, more ambitious emission reductions from additional policies and measures (WAM).

Here, we conduct a GHG inventory for emissions for the agriculture and the Land Use, Land-Use Change, and Forestry (LULUCF) sectors of the Republic of Kosovo (hereafter Kosovo). We use the Intergovernmental Panel on Climate Change (IPCC) GHG Inventory Software and implement the national GHG Inventory for agriculture and LULUCF at Tier 1 for Kosovo, following the methodologies laid out in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC 2006). For historical accounting, we used the official statistics available for the period from 2017 to 2021. We synthesise existing policy measures by scrutinising government strategies for this period, particularly the Agriculture and Rural Development Strategy 2022-2028 (MAFRD 2021c) and the Policy and Strategy on Forestry Development in Kosovo 2022-2030 (MAFRD 2021b), augmented with additional government documents and qualitative insights from sector experts gained during a field trip in March 2023 and follow-up interactions. To project future emission pathways, we implement the WEM in the GHG inventory and use them to project emissions until 2030. The simulations are then conducted to suggest additional concrete and quantitative measures in the WAM. Therefore, we simulate additional, more ambitious policies and measures (WAM) assuming steps toward further reduction of the GHG emission balance compared to WEM. In the next step, we select the ten strategies from the WEM simulations that have the greatest potential to reduce emissions or improve sinks.

The LULUCF sector is arguably large enough to provide long-term climate benefits for the achievement of the Kosovo greenhouse gas emission reduction objectives. In addition, the

LULUCF sector serves as a source of biobased materials that can replace fossil fuels or carbon-intensive materials, thus playing a crucial role in the shift towards a low-emission economy. Changes in forest management have ample potential to mitigate climate change by reducing emissions by providing stable sinks and increasing carbon stocks through additional sequestration of CO_2 in soil and vegetation biomass. Sustainable forest management practises can also generate co-benefits, such as bolstering resilience of livelihoods of land users, enhancing soil productivity, improving water cycles and air quality, and providing habitat for flora and fauna. This, in turn, provides stimulus for economic and social development while simultaneously reducing the carbon and ecological footprint of the LULUCF sector.

2. Background of the AFOLU Sector

2.1 LULUCF

Kosovo still lacks a land monitoring system (KEPA 2021) and therefore there are no statistically validated land cover data available. The most up-to-date land-cover estimates from satellite imagery are from 2018 and follow the Coordination of Information on the Environment (CORINE) methodology (KEPA 2021). These data suggest that 57% of forests and semi-natural areas and 38% of agricultural areas.

Substantial changes in the extent of arable land were not observed between 2012 and 2018 (KEPA 2021). Interviews with local experts suggest some abandonment of more marginal areas, while most fertile lands continue to be used. The expansion of the built areas had consumed some of the best arable land, particularly around the capital of Kosovo, Pristina, but this change in land cover is negligible in absolute terms.

Pastures are mainly state property and are used as communal land by livestock herders. The pastures are used predominantly for grazing sheep. The number of sheep and goats increased, according to the Kosovo Statistics Agency (KAS), from 211,000 in 2017 to 241,000 in 2021 (KAS 2023). Combined, the meadows, which are used to cut grass to feed cattle, and the pastures covered 217,000 ha in 2021.

According to the latest forest inventory (a new forest inventory has been in planning, but work has not begun yet in spring 2023), forests covered 45% of the territory of Kosovo in 2012 with a standing volume of 41 million m^3 (Tomter et al. 2013). 84% of this forest is coppice and almost all the forest is broadleaved; the 5% of coniferous forests are found mainly at high altitudes. The growing stock averages 84 m^3/ha and the annual increment amounted to 3.2 m^3/ha (Tomter et al. 2013). Since then, overall forest cover has arguably remained stable (personal communication with forestry experts from Kosovo). 62% of the forest area is in state ownership, of which 12% are in protected areas and 38% are in private ownership (MAFRD 2022). Forest areas experience regular wildfires, largely ignited by human sources but facilitated by hot and dry weather for longer periods. In 2021, fires affected 2,653 ha of forests; 2,080 ha (almost 80%) of the fires occurred on state-owned forest land (MAFRD 2022). However, through natural regeneration, most biomass in burnt forests recovers quickly, usually in a few years (personal communication with forest experts).

Forest resources constitute a key resource for most rural households in Kosovo through the extraction of firewood. Most of this extraction occurs on government-owned forest land where firewood extraction is illegal. Small-scale businesses carry out most of the extraction and sell the firewood in informal markets in small settlements and the cities. FAO estimated total firewood consumption at 2.1 million m^3 in 2012 (Krajnc et al. 2015). Approximately 90% of rural households completely depend on the extraction of forest biomass as firewood for heating and approximately one third of urban households use wood biomass, mainly at the fringes of smaller cities. The average wood consumption per household and year is about 8 m^3 (Krajnc et al. 2015). With 1.09 million rural households and 0.72 million urban households in 2021 (data from the Model for Analysis of Energy Demand, MAED), this sums up to 1.81 million m^3 of firewood that were consumed in 2021.

Firewood extraction that exceeds regrowth reduces the volume of biomass in forests and may be partly associated with clearings, which, according to our interviews, are limited in extent. To obtain the total annual increment, we multiply the increase in annual forest biomass of 3.22 m^3/ha with the biomass expansion factor (BEF) of 1.4 for broadleaf forests (Tomter et al. 2013) and with the 481,000 ha of forests (BEF converts the annual net increment including bark to the total increment in above-ground tree biomass)). This amounts to a total annual increment of 2.17 million m^3 in 2021. After subtracting the firewood extraction of 1.81 million m^3, 0.36 million m^3 or 17% of the total forest biomass remains as annual increment.

Most of the firewood is purchased up to two months before the heating season, leaving little time for the wood to dry. However, dried wood generates more heat and therefore more firewood is needed to generate the same heat output (Krajnc et al. 2015). Firewood consumption has slowly fallen during the 2010s due to the decline in the rural population. However, anecdotal evidence suggests that rising energy prices in 2022 have contributed to a rise in firewood purchases in response to higher energy prices and the fear of a lack of electricity supply. Other uses of wood remain negligible, according to our interviews with experts.

2.2 Agriculture

In 2021, agriculture, hunting, forestry, and fishing was the fourth largest sector, contributing 7% to the GDP of Kosovo (World Bank 2023). Compared to 2008, the contribution of the sector to GDP decreased by 4.4%, suggesting that other sectors of the economy are gradually increasing in importance at the expense of agriculture. However, agriculture remains a mainstay of the economy; 60% of the population live in rural areas and most of those are engaged in agriculture.

Agricultural policies favour larger farms with competitive advantages due to economies of scale. However, the average farm size remains small, with 1.7 ha, 70% of the farms are smaller than 2 ha, and more than 90% are smaller than 5 ha (KAS 2023). Small farms are the main producers and play an important role in contributing to the productivity and sustainability of the sector, as well as to the goals of rural economic development.

The country's total utilized agricultural area (UAA) in 2021 was 420,327 ha; pastures and meadows (including common land) occupy 52%, followed by arable land with 45%, tree plantations 2%, and vineyards 0.8% (MAFRD 2022). Cultivated areas have increased slightly between 2014 and 2021, particularly fruit orchards, vegetables, and vineyards.

Arable land covers 155,000 ha, of which 52% (80,000 ha) is used for wheat cultivation, 26% (40,000 ha) for maize, 13% for vegetable cultivation, and 7% for fruit trees (KAS 2023). The Master Plan for Irrigation in Kosovo (2021a) indicates that 20,000 ha of 280,000 ha are currently irrigated with the potential to develop an irrigation system. Crop productivity remains about 50% below the levels achieved in central Europe despite a large share of fertile soils.

Crop residues are collected in parts and used for animal feed, mainly as straw. Some residues are ploughed into the soil, and some are burnt. Unfortunately, we do not have statistics on crop residue management. All chemical fertilisers are imported; Imports amounted to 55,5 million kilogrammes (kg) in 2021. If distributed equally across all 104,000 farms and assuming a nitrogen (N) content of 20%, this amounts to 44 kg N per hectare of arable land (for comparison, 226 kg N per hectare were applied from 2015 to 2017 in Germany; UBA 2019).

The numbers of cattle have remained stable since 2017 and comprised 261,000 cattle heads in 2021 of which 51% are used for dairy production, 211,000 sheep, and 30,000 goats (KAS 2023). Personal communications with experts from the Ministry of Agriculture and Rural Development (MAFRD) suggest that livestock numbers tend to decrease on smaller farms, while larger farms enlarge their livestock herds. Small farmers usually have up to a handful of cattle, which live largely outside. These small livestock farms produce at high GHG emission intensity, that is, the GHG emissions per unit of output. Most cattle are owned by larger, commercially orientated cattle farms, which typically focus on dairy production. They usually keep the cattle inside stables all year, resulting in lower GHG emissions per unit of production, i.e., lower emission intensity. Different types of manure management between small and large farms are relevant for emission accounting. Most manure on larger farms (with ten or more cattle) must be collected and stored in depots; personal communication at MAFRD suggests that about 90% of the larger farms use such storage facilities for manure, which they then apply to the fields in spring or fall.

Kosovo's trade regime is liberal and orientated towards supporting the competitiveness of the economy. However, trade deficits have increased in the last decade and trade now represents 82% of Kosovo's GDP (OECD 2021). The trade deficit for agricultural products in 2021 was 687.3 million Euro (MAFRD 2022), with agricultural imports accounting for 23% of total imports. Stipulated by the EU Autonomous Trade Preference (ATP) regime, Kosovo enjoys non-reciprocal, customs-free access to the EU market. However, for some food products, such as wine and beef, numerous restrictions remain in force.

The low self-sufficiency rate of the Kosovo agricultural sector implies that substantial GHG emissions, which originate in the places of production, are embedded in agricultural imports. Wheat self-sufficiency has been below 70% in 2021, and the remaining demand must be met by imports. With a per capita consumption of 25.5 kg per year, self-sufficiency in beef production was 44% in 2021; therefore, substantial emissions are associated with imported beef (MAFRD 2022).

2.3 GHG Emissions

The Kosovo Environmental Protection Agency (KEPA) has conducted a GHG accounting for 2019 using the 2006 IPCC standards (MAFRD 2022). The estimated total GHG emissions were 9,600 gigagrammes (Gg) of CO_2-equivalents (CO2eq), of which 8% (770 Gg of CO_2eq) were due to the AFOLU sector.

The agricultural sector predominantly emits methane (CH_4) and nitrous oxide (N_2O). CH_4 originates primarily from the digestive processes of ruminant livestock through enteric fermentation. N_2O comes from organic and inorganic fertilisers, including manure management and artificial fertiliser applications. Four quarters of agricultural emissions originated from livestock production in 2019, according to KEPA estimates, including 67% of enteric CH_4 fermentation (MAFRD 2022).

Kosovo used to have Europe's highest annual felling rate, that is, felling as a fraction of net annual increment (from the State of Europe's Forests 2011, cited in Tomter et al. 2013). The forestry sector was considered a sink with an estimated sequestration of 39 Gg CO_2eq in 2019 (MAFRD 2022). Emissions and removals from forest land are influenced by various location factors, including, but not limited to, forest species composition, age-related forest attributes, and management practises, all of which vary significantly in Kosovo. Forestry activities and policies that aim to reduce emissions or improve sinks need to consider local circumstances. Furthermore, forest resources in the Balkans are increasingly threatened by wildfires. Without adaptation measures, such as prescribed burning, burnt areas can increase between 2.5-fold and 6.6-fold until 2090 (Khabarov et al. 2016). Promising measures to improve forest carbon stocks need to consider pressures arising from climate change, such as more frequent heat and drought, which can lead to increased fire activity.

2.4 Expected Land Use Changes until 2030 in Business as Usual

2.4.1 LULUCF

Our interviews with sectoral experts revealed broad qualitative expectations about the expected changes in land cover in Kosovo. In terms of forest cover, a slight increase is expected due to the reduction of pressure on forest resources due to the lower demand for firewood, the expected reduction in illegal logging, and because some more marginal areas will be available for reforestation. However, in the absence of targeted silvicultural measures to aid in the natural regeneration of forests, the quality of the forest can decrease. According to experts, afforestation will not be a promising strategy because most areas are not suitable for the establishment of new forests and because nurseries that provide quality seedlings are lacking.

Some agricultural land in hilly and mountainous areas may be abandoned due to the emigration of households from these more remote places, although this process will arguably only affect small areas. Some pastures, particularly in more remote areas, may also become abandoned over time due to the expected reduction in the number of sheep with the decline of shepherds.

2.4.2 Agriculture

Agricultural structures are expected to undergo substantial changes until 2030. The number of small farms is expected to shrink, as many farmers migrate to urban areas or internationally (Sauer, Gorton and Davidova 2019). Some marginal arable land, as well as some pastures, will probably be abandoned. More fertile agricultural areas will continue to be used, but by fewer and larger farms, due to an expected increase in average farm size. Agricultural policies, such as the Law on Land Consolidation and the Law on Agricultural Land, which is currently in preparation, will include a tax on not using land with the aim to facilitate land consolidation towards fewer farms with larger average farm size. Cattle numbers are expected to rise slightly again (personal communication with experts from MAFRD).

As a result of the expected structural change in the agricultural sector, agriculture will likely become more efficient in terms of land productivity and hence in terms of greenhouse gas efficiency, i.e., more output per unit of carbon dioxide equivalent. For example, livestock production in market-orientated farms occurs in stables and relies on feed and fodder inputs grown in the field, which in turn are fertilised by cattle manure, augmented with higher input applications in chemical fertilisers. Similarly, more fertiliser application will increase crop yields and reduce GHG emissions per unit of crop output until a turning point, when plants cannot take up the additional fertiliser, which will then be partly emitted as N_2O (Guo, Liu and He 2022).

3. Data and Methods

To model the GHG emissions from the AFOLU sector, we use the best available data for land use, agricultural practices, and forestry. All data for the baseline emissions accounting come from official statistical sources. Unfortunately, statistical data are limited in Kosovo; longer time series and subnational data are not available for many variables. Furthermore, the simulated long-term trends in GHG emissions are marred with substantial uncertainty. Activity data for the LULUCF sector are also largely missing. Therefore, we take a pragmatic approach and use a Tier 1 approach. When national data were lacking, we used the default IPCC values.

3.1 GHG Inventory Method

We use IPCC emission accounting software (version 2.83) for all calculations (IPCC 2022). The software allows quantifying agriculture and LULUCF emissions based on activity data and emission factors. The software implements the 2006 IPCC Guidelines for National Greenhouse Gas Inventory with methodologies at the levels of Tier 1, Tier 2, and Tier 3 and is suitable for establishing national GHG inventory. The software consists of worksheets where activity and emission factor data can be entered and supports quality control, data import and export, as well as reporting (IPCC 2022).

3.2 LULUCF

LULUCF activities can be constituting as a source that emits and as a sink that removes CO_2 from the atmosphere. Due to the lack of consistent activity data for land-based GHG emission calculations, we abstract from accounting for changes in the remaining IPCC land cover categories required in the emission inventory, such as changes in cropland, grassland, wetlands, settlements, and other land. Therefore, we focus on the changes in the forestry sector.

Changes in forested areas and changes in forest biomass density define increments and removals. The removals in Kosovo consist mainly of the harvesting of wood products, especially through the removal of firewood, which reduces biomass in forests and contributes to large CO_2 and some non-CO_2 emissions. We also account for reforestation, that is, the reestablishment of trees on formerly forested lands. We exclude the inclusion of afforestation scenarios because the forest experts we met in Kosovo postulated that all areas, which have not been forested in recent years, are not suitable for the growth of trees. This goes against the 2018-2027 National Afforestation and Reforestation Programme (MAFRD 2016), which envisaged 18,000 ha of afforestation between 2022 and 2027. We also consider the emission of forest fires if 70% of the burnt biomass is emitted as CO_2 (personal communication).

We used the IPCC methodology (IPCC 2006) to estimate emissions and removals in the forestry sector. Where possible, country-specific data was used (Tier 2); when national data was not available, we resorted to IPCC default values (Tier 1). Our calculation refers only to living biomass. In Tier 1, it is assumed that the carbon stock in the mineral soil remains constant when the forest area remains forest, regardless of changes in forest management, forest types, and any other disturbances. The main source of country-specific data on tree species, forest management, forest disturbances, and forest resource growth is the detailed forest inventory of Kosovo of 2012 (Tomter et al. 2013). Unfortunately, it is not clear how the forests of Kosovo have changed since then, according to the forest experts we have interviewed. Therefore, it is important to note that our accounting for GHG of the forestry sector mainly reflects the situation in 2012, which was captured by the last forest inventory. For some activities, such as the extraction of firewood and forest fires, we used more recent data (see below).

To estimate changes in forest biomass with the IPCC software, we used forest types, growing stock and forest increment from the 2012 forest inventory (Tomter et al. 2013) and forest area for 2021 (KAS 2023). Since almost 83% of the forest area is pure broadleaved forests and because detailed data are only available for this category, we parametrised the model only for the broadleaf category, which we keep stable at 83% of the forest cover. The annual increment in bark of trees with a diameter at breast height (DBH) larger than 7 cm is estimated at 1.32 million m^3 for broadleaved trees and 0.23 million of coniferous trees (Tomter et al. 2013). We use these and other key parameters to calculate forest biomass, that is, the density of wood, the biomass expansion factor, and the root-to-shoot ratio. We have extracted these data from the Kosovo Forest Inventory (Table 14 in Tomter et al. 2013). We used the IPCC default factor for the conversion of dry matter to carbon (CF = 0.47).

The loss of wood biomass in Kosovo is due to the legal and especially illegal extraction of firewood, as well as widespread forest fires. In the 2012 forest inventory, the total annual harvest, mainly as firewood, was estimated at 1.6 million m^3. To better cover recent trends, we calculated firewood use based on MAED and Eurostat Energy Balances. Using demographic data and balances for energy supply and demand, we calculate historical (2017-2021) and projected (2022-2040) firewood use. In 2021, our baseline year, we estimate an extraction of 1.81 million m^3 of firewood. Due to demographic and economic trends, firewood use is projected to decrease to 1.65 million m^3 per year until 2030 (-9% compared to 2021), and to 1.49 million m^3 in 2040, suggesting a growing carbon sink due to lower extractions.

Under extreme weather conditions and limited fire protection capacities in Kosovo, forest fires can be widespread. For example, in 2012, an extremely dry and hot year, an area of 12,200 ha (2.5% of the total forest area), was affected by fire (Tomter et al. 2013). However, forest fires were substantially lower in the following years, with 2,650 ha in our baseline year 2021 (MAFRD 2022). According to the forest experts interviewed, approximately 70% of forest biomass is fully burnt during fire events. Therefore, we set the parameter ‘fraction of biomass burnt’ to 0.7. Following the IPCC guidelines, we estimate CO_2 and CH_4 as ratios to carbon released during burning, and N_2O and nitrous oxide (NO_x) emissions as ratios to total nitrogen released.

3.3 Agriculture

3.3.1 Enteric Fermentation

CH_4 is a direct product of animal metabolism generated during the digestion process. The largest CH_4 producers are ruminants (cows, other cattle, and sheep). The amount of CH_4 produced and excreted depends on the animal digestive system and the amount and type of animal feed. Because Kosovo-specific data on livestock activity and energy demands are absent, we used the default emission factors suggested by the IPCC Guidelines (IPCC 2006) to estimate CH_4 emissions from enteric fermentation. Our inventory assessment captures only CH_4 emissions from main farm animals (cattle, sheep, and goats). We excluded CH_4 estimates from poultry because the estimation method was not developed and no default emission factor was provided for the Tier 1 method by the 2006 IPCC Guidelines (IPCC 2006).

CH_4 emissions from enteric fermentation are strongly dependent on temperature. Kosovo is primarily in the "cool" climate zone, with a median temperature of 9.5°C (https://en.wikipedia.org/wiki/Climate_of_Kosovo). The Kosovo Agency of Statistics (KAS) provided national data for the population numbers of all types of livestock. Temperature and population numbers were included in the IPCC software.

3.3.2 Management of Manure

CH_4 and N_2O emissions are the two main GHG emissions resulting from the management of livestock manure. The magnitude of the emissions depends on the amount of manure handled, the properties of the manure, and the type of manure management system. CH_4 is generated under conditions of anaerobic decomposition of manure. Manure storage methods, such as liquid animal manure in septic tanks in which anaerobic conditions prevail, favour anaerobic decomposition of the organic substance and, therefore, release CH_4. Direct N_2O emissions from manure management can occur through combined nitrification (under aerobic conditions) and denitrification (an anaerobic process) of nitrogen contained in manure. The N2O emissions of manure during storage and treatment depend on the nitrogen and carbon content of manure, the weather conditions, the duration of storage and the type of treatment. Typically, poorly aerated manure management systems generate large amounts of CH_4 but smaller amounts of N_2O, while well aerated systems generate little CH_4 but a larger volume of N_2O. Therefore, information on manure management systems is essential for a reliable estimate of agricultural emissions.

We have obtained information on the proportions of livestock in the various manure management systems (e.g., solid storage) from KEPA. For all animals, we used the 2006 IPCC Tier 1 methodology and IPCC default values to calculate CH_4 emissions from manure management. Country-specific data, such as the emission factor, were not available to us.

3.3.3 Agricultural Soils

Agricultural soils are the largest anthropogenic source of nitrous oxide (N_2O) emissions. Nitrous oxide is produced naturally in soils through the microbial processes of nitrification and denitrification. Agricultural activities such as fertilisation and crop cultivation add nitrogen to the soils, increasing the amount of N_2O released into the atmosphere. Anthropogenic N_2O emissions from agriculture occur either directly through nitrogen input into soils or indirectly after nitrogen is removed from the soils. Direct N_2O emissions from agricultural soils are due to the application of synthetic fertilisers and animal manure used as fertilisers. Furthermore, direct N_2O is released due to the decomposition of crop residues that remain in the soils and due to the cultivation of organic soils.

For the estimation of N_2O emissions from the use of synthetic fertilisers, the Tier 1 methodology suggested by the IPCC Guidelines was applied. We estimate direct N_2O emissions from agricultural soils. The main input variable is the amount of N applied per year. N input is sourced from manure, synthetic fertilisers, and crop residues. As we did not have application rates of (N per hectare) by mineral fertiliser, we used statistics of imported synthetic fertilisers to approximate the application per hectare of synthetic N. Kosovo does not produce mineral fertiliser domestically and is fully dependent on fertiliser imports. We assumed that all fertiliser imports are applied to fields and that no fertiliser is (re)exported (which was confirmed by expert interviews in Kosovo). Suppose that the N content of imported mineral fertiliser is 20% and that the fertiliser is evenly distributed over 267.000 acres of arable land, the average application of N was 42 kg N per hectare in 2021.

The Tier 1 methodology was applied for the estimation of N_2O emissions from the use of animal manure as fertiliser. Specifically, we calculate total nitrogen excretion from animals and correct it to account for the fraction that volatizes in ammonia and nitrogen oxides and the fraction that is deposited in soils through pasture, range, and paddock systems. We also calculated indirect N_2O emissions from agricultural soils, which are released due to the volatilisation of nitrogen included in synthetic fertilisers and animal manure, as well as by atmospheric deposition such as NO_x, nitric acid (HNO_3), and ammonium (NH_4) on soils and surface waters and subsequent N_2O formation. The emission factors used are the default ones suggested by IPCC. The emission factor for atmospheric deposition reflects the fraction of nitrogen volatiles such as ammonia and nitrous oxides, while for leaching and runoff it reflects the fraction of nitrogen leaks from synthetic fertilisers and animal manure.

We also estimate the input N and the associated N_2O emissions of crop residues. The generation of crop residues is the result of the agricultural practises used. Disposal practises for residues include ploughing them back into the ground, composting, landfilling, and burning on site. According to the IPCC Guidelines, 20% constitutes an indicative value of the residues burnt annually in the field. The burning of agricultural residues is responsible for the emissions of CH_4, N_2O, and NO_x. We used IPCC standard values for residue-to-crop ratios, dry matter fractions, the carbon fraction of residue, and the nitrogen-carbon ratio for each type of crop. For calculating the fraction burnt in fields, we used the default IPCC value (0.2) with an oxidised fraction of 0.9. On the one hand, higher yields result in larger amounts of crop residues and thus higher N_2O emissions. On the other hand, crop residues can lead to accumulation of humus and thus sequestration of C from soils. However, we have not been able to consider changes in C pools due to change in land use and residues, due to lack of data.

3.4 Scenarios with Existing Measures (WEM)

In 2022, the government of Kosovo approved its second seven-year Strategy for Agriculture and Rural Development (SARD) for the period 2022 to 2028 (MAFRD 2021c). The design of the SARD focusses on four strategic objectives:

1. Increasing the competitiveness of the agri-food sector and improving the efficiency and sustainability of farm production.
2. Sustainable management of natural resources (land, forests, and water).
3. Supporting businesses in rural areas and improving employment and social infrastructure.
4. Comprehensive institutional and sector reform to create efficient public services.

Under the EU instrument for pre-accession assistance for rural development (IPARD) for Kosovo, the Action Document of IPARD III for the period 2021 to 2027 is under finalisation. MAFRD clearly emphasised that support for the agricultural sector should be aligned with the IPARD III programme and reviewed in this perspective. Therefore, the strategic objectives of the SARD are in line with the objectives of IPARD III, which include the following:

1. Increase the competitiveness of the agri-food sector, progressively aligning it with the EU standards, and improving the efficiency and sustainability of on-farm production;
2. Facilitate business development, growth, and employment in rural areas, improve farmers' position in the value chain, and attract young farmers;

3. Contribute to the mitigation of climate change and promote sustainable management of natural resources;

4. Improve community development and social capital in rural areas and build modern public administration for agriculture and rural development, respecting the principles of good governance.

3.4.1 LULUCF

We used information from key strategic documents and interviews with sector experts to establish the scenario with existing policies and measures (WEM). These documents include the Policy and Strategy on Forestry Development in Kosovo 2022-2030 (MAFRD 2021b). We did not account for the goals presented in the National Forest and Reforestation Programme (MAFRD 2016) because foresters, i.e., the establishment of trees where there was no tree before, did not consider it relevant. The reforestation target in this programme of 4,400 ha from 2022 to 2027 has been replaced by the goals of the Forest Development Policy and Strategy (MAFRD 2021b).

In general, the experts consulted had mixed opinions on how realistic the targets of the forest strategy are; judgements ranged from 'wishful thinking' to 'quite probable' that the targets can be achieved. There was broad agreement that natural regeneration of degraded forests is probably the main contributor to greater carbon storage in forest biomass. Afforestation will probably not be important because few non-forested and unused areas are suitable for growing forests. Better protection of forests on public land has been named a useful protection strategy, but no numbers were given.

The forest strategy states the goal of reducing illegal logging by 70% until 2030 and an increase in forest area by 3% between 2022 and 2030. Other measures include using more efficient wood stoves that use 50% less biomass per unit of energy, produce more pellets, and establish forest management plans for the 140,000 private forest owners. The latter are implemented in the projections for firewood use, and hence indirectly accounted for in the scenarios on firewood extraction. The policies and measures (PaMs) in forestry are summarised in Table A 2, Table A 3 and Table A 4).

3.4.2 Agriculture

The SARD 2022-2028 (MAFRD 2021c) lacks quantitative targets, so we establish such targets based on our expert interviews. Some agricultural land will be lost to built-up land, but these areas only cover a small area, and thus are not negligible for emission accounting. The soon to be implemented land tax for not using cropland will counteract abandonment and facilitate increases in average farm size. The stated objective of this policy is zero abandonment. Unequivocally, all experts expect a consolidation of agricultural holdings towards larger average farm sizes and higher agricultural efficiency.

Most pastures will continue to be used in the future, according to experts, although the intensity of grazing (animals per unit of area) will decrease. Some more marginal pastures will probably be abandoned due to the expected lower number of sheep by 2030. However, pasture abandonment will probably have few effects on carbon stocks because most of these lands are natural grasslands that are at higher altitudes, poor soils, and in remote areas. Therefore, abandoned pastures will not provide promising options for afforestation or carbon sequestration in other pools.

There are plans to increase livestock production with additional substantial government investments. Small dairy producers, that is, those with five cows or less, will disappear largely by 2030, according to experts from the Agricultural Ministry. As a result of the higher efficiency, particularly in dairy production, the intensity of emissions (i.e. GHG emissions per unit of produce) will decrease. Additionally, larger farms are more prone to manure storage. In crop production, larger farms will apply higher amounts of fertiliser per hectare, and hence have larger emissions (again, target numbers on this are lacking in the SARD).

Higher digitalisation and precision farming will foster efficiency gains (and probably reduce fertiliser emissions per unit of fertiliser application). The productivity of the agricultural sector remains low compared to neighbouring Serbia and EU countries. This is mainly due to outdated and insufficient machinery, lack of agricultural knowledge and skills, and poor quality of agricultural input (MAFRD 2021c). With increasing international emigration and internal migration from rural to urban areas, wages in the agricultural sector are prone to increase in the future. Therefore, the improvement of labour-saving technical change, including digitalisation, will likely become increasingly crucial. The PaMs for agriculture are summarised in Table A 5, Table A 6, and Table A 7).

3.5 Scenarios with Additional Measures (WAM)

We engaged with government officials and stakeholders in Kosovo to identify additional and more ambitious policy options for further reductions in emissions in the LULUCF and agricultural sectors. However, we were unable to obtain quantitative estimates from experts that we could implement in the WAM calculations of GHG emissions.

Table 1: Quantification of WEM and WAM scenarios in 2030 relative to the 2021 baseline

Measure	Quantification	Scenario
Increasing biomass increment	n.a.	WEM
	+10% (3.22 to 3.54 m^3/ha)	WAM
Decreasing firewood removal	-11% (1,862,128 to 1,654,128 m^3)	WEM
	-20% (1,862,128 to 1,500,000 m^3)	WAM
Decreasing area of forest fires	-25% (2,653 to 2,000 ha)	WEM
	-62% (2,653 to 1,000 ha)	WAM
Decreasing area of cropland fires	-50% (40,000 ha to 20,000 ha)	WEM
	-75% (40,000 ha to 10,000 ha)	WAM

Measure	Quantification	Scenario
Increasing N-fertilisation rate	+129% (43.66 to 100 kg N/ha)	WEM
	+244% (43.66 to 150 kg N/ha)	WAM
More efficient manure management	+20% daily spread MMS	WEM
	+20% daily spread MMS; +20% anaerobic lagoons	WAM
Livestock reduction (cattle, sheep, goats, poultry)	-10% of all livestock	WEM
	-20% of all livestock	WAM
Higher removal of residues	+10% (from 20% to 30% removal)	WAM

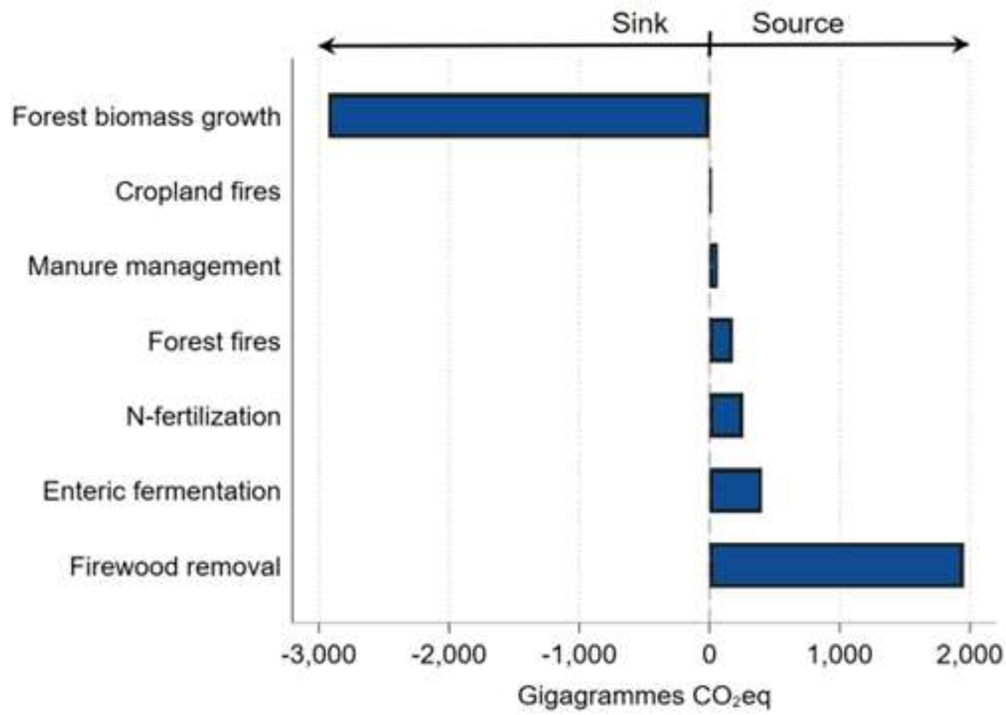
Source: Own elaboration. Note that we assumed that the biomass increment remains constant under WEM compared to the baseline.

4. Results

4.1 Baseline Emissions

In general, the AFOLU sector was a small GHG sink in Kosovo with a withdrawal of 51 Gg of CO_2eq in the baseline year 2021. Overall, agricultural activities emitted 742 Gg of CO_2eq, while the forestry sector sequestered 792 Gg of CO_2 from the atmosphere (Figure 1). The increase in forest biomass through annual increment sequestered almost 3,000 Gg of CO_2 in 2021 while the removal of firewood caused emissions of almost 2,000 Gg of CO_2 and forest fires were responsible for emissions of 180 Gg of CO2.

Figure 1: Baseline emissions and removals in the AFULO sector in 2021



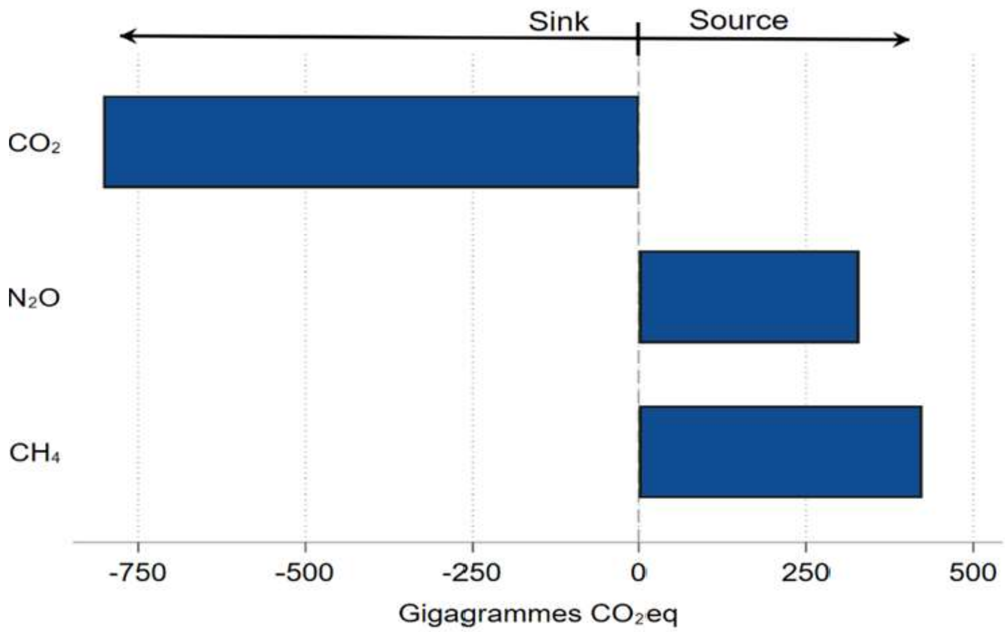
Source: Own calculations.

The low sink, despite the extensive and productive forests of Kosovo, is due to one of the highest rates of timber extraction in Europe. The extent of illegal logging may even be somewhat underestimated as firewood extractions have been estimated conservatively, which would further minimise the small carbon sink or even turn the forests into a source (Tomter et al. 2013). In any case, reducing illegal logging for firewood extraction offers great potential for mitigation of greenhouse gases.

The livestock sector, particularly CH_4 emissions from enteric fermentation (402 Gg CO_2), was the largest contributor to GHG emissions from agriculture. Here, dairy cows and other cattle are responsible for 91% of the total GHG emissions from livestock production. N_2O emissions due to the application of mineral fertilisers were low in the baseline year due to low fertiliser inputs and a small area under cultivation. However, low crop yields result in high emissions per unit of output of crops. Higher fertiliser rates, and thus higher yields, can reduce GHG emissions per unit of output (see Section 4.2).

Broken down by the main categories of GHG, CO_2 provides a net sink of 800 Gg, while CH_4 contributes to total emissions of 423 CO_2eq and N_2O is responsible for 328 CO_2eq (Figure 2).

Figure 2: Baseline emissions in 2021 by major GHG categories

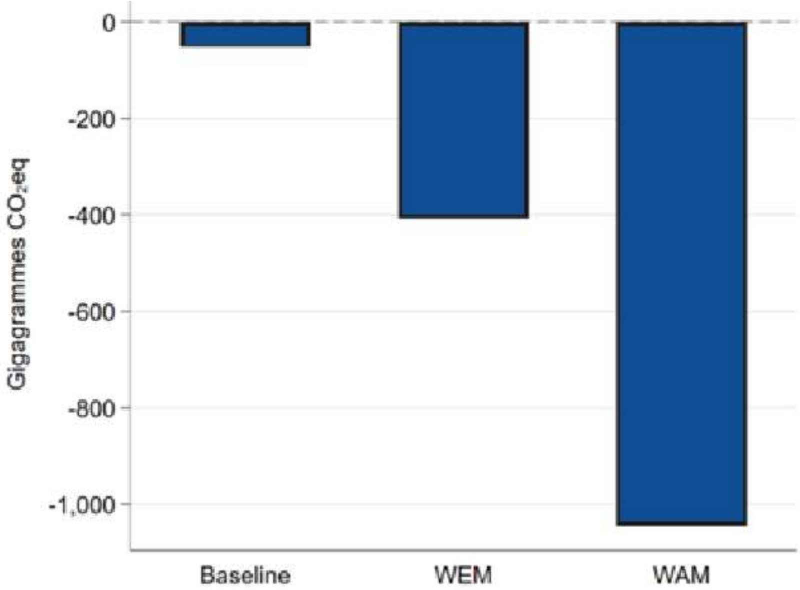


Source: Own calculations

4.2 Scenarios

WEM and WAM scenarios substantially enlarge the AFOLU sink. In the WEM, the sink increases to 407 Gg CO_2eq and in the WAM scenario 1,045 Gg CO_2eq is taken out of the atmosphere through land use (Figure 3).

Figure 3: Net GHG emissions at the 2021 baseline and in WEM and WAM in 2030

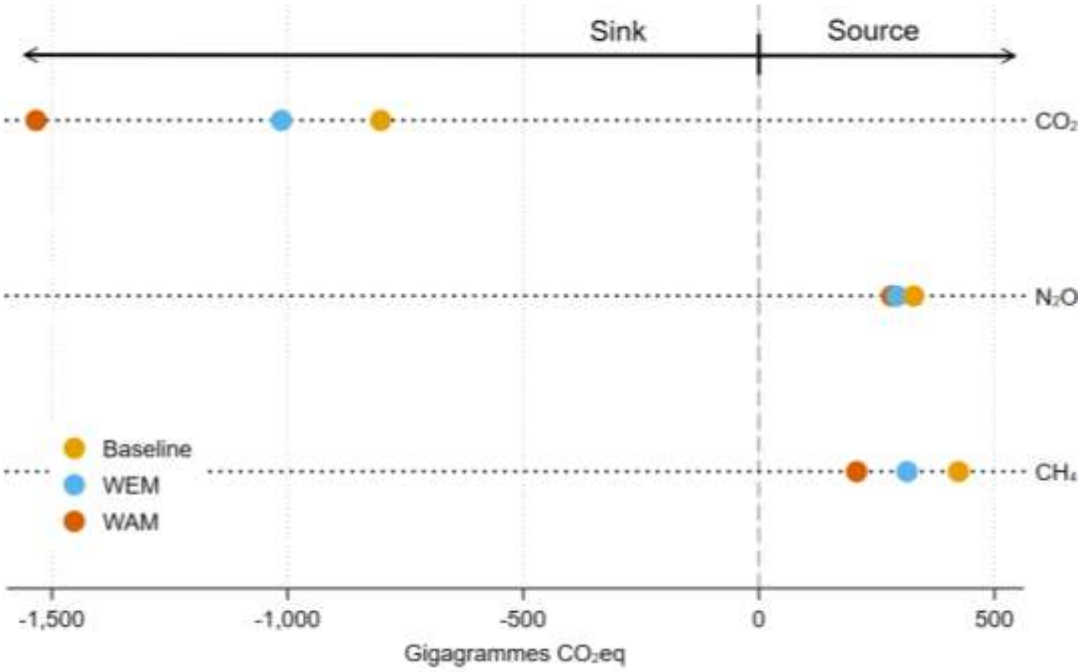


Source: Own calculations.

Most of the improvement in the GHG sink can be achieved by increasing CO_2 sequestration in forest biomass (Figure 4). The WEM scenario provides 211 Gg CO_2. The anticipated small decrease in firewood removal in the WEM scenario (-11% relative to baseline) results in large absolute increases in the carbon sink, highlighting the effectiveness of climate mitigation of targeted policy measures in the forestry sector. In the WAM, we assume a lower amount of firewood removal (-20% relative to the baseline) in combination with a 10% higher forest biomass productivity (Table 1), which substantially improves the mitigation potential in this scenario. With additional policy measures (WAM) in the LULUCF sector, 521 Gg of CO_2 could be removed from the atmosphere beyond the WEM scenario.

Reducing CH_4 emissions, mainly through lower livestock numbers, contributes 109 Gg CO_2eq in the WEM (10% fewer livestock; see Table 1) and an additional reduction of 107 Gg CO_2eq in the WAM (-20% of livestock; see Table 1). N_2O emissions contract by 36 GgCO_2eq in WEM and by an additional 11 GgCO_2eq in WAM (Figure 4).

Figure 4: AFOLU emissions at baseline (2021), WEM (2030), and WAM (2030) by GHG gas



Source: Own calculations.

4.2.1 LULUCF

Emission accounting underscores the importance of the forestry sector (activity data for the other land cover categories are lacking, but these other categories would not substantially affect the emission estimate due to their low coverage, little change in extent, and low emission factors).

The two key variables that determine the sink-source relationship in the forestry sector, first, biomass growth, shaped by the natural increment rate and changes in the forest area, and second, forest biomass extraction by humans, mainly through firewood extraction in Kosovo. Forest fires only affected small areas in Kosovo; the anticipated 25% reduction in forest fires in the WEM from 2,653 observed in 2021 to 2,000 ha (Table 1) and from 62% to 1,000 ha in the WAM do not have substantial effects on overall emissions (Figure 5). However, there is a risk that larger forest fires, as occurred in some previous years (e.g., in 2012 forest fires affected more than 12,000 ha), will abruptly reduce the carbon sink of forests in Kosovo.

The growth of forest biomass can be enhanced through enrichment planting, integrated forest management, and silviculture treatment that aims to improve the biomass content (Table A 2). Furthermore, better protection of existing forest resources contributes to reducing pressures and extraction activities, particularly by successfully reducing illegal logging and reducing forest fires (Table 3) shows that the magnitude of the mitigation potentials from reducing wood extraction and increasing biomass productivity in forests is similar in the baseline and in the WEM and WAM scenarios.

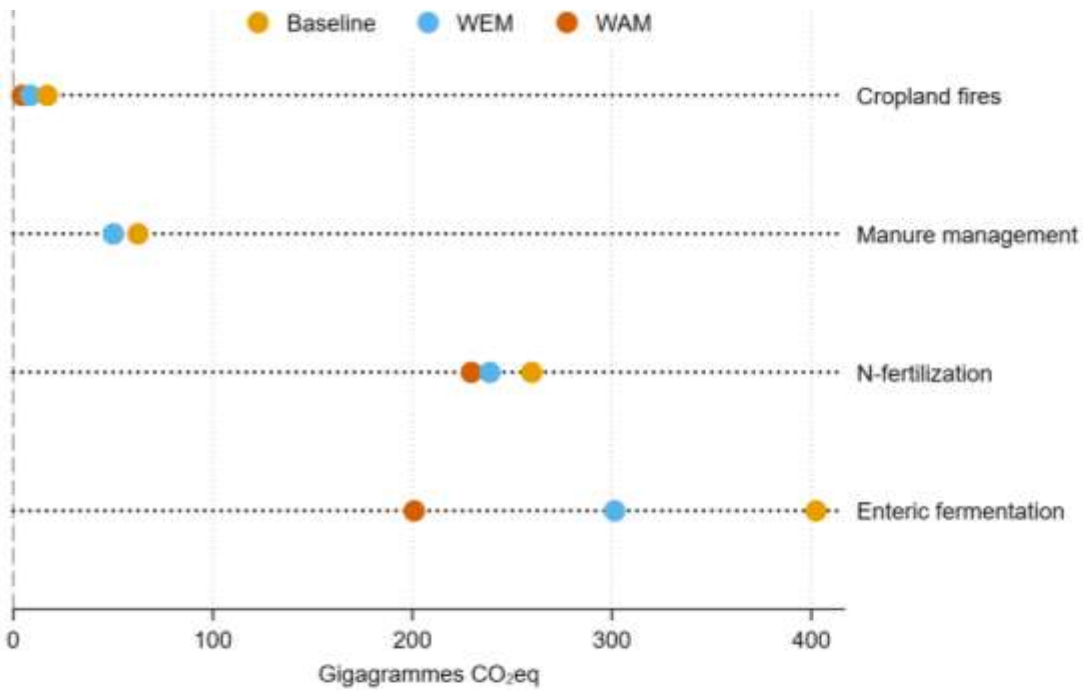
4.2.2 Agriculture

Changes in the number of ruminant cattle have substantial impacts on AFOLU emissions; All other changes in agricultural practises in the WEM and WAM scenarios have less impact on emissions (Figure 6). Cattle are responsible for 91% of livestock related GHG emissions, 81% of which are CH_4 emissions from enteric fermentation.

Increasing the amount of mineral fertiliser from 42 kg N per ha in the baseline (2021) to 100 kg N per ha (WEM) and 150 kg N per ha in the WAM scenario (Table 1) results in GHG savings of 14 Gg CO_2eq and 17 Gg CO_2eq, respectively. Thus, the intensification of agriculture through higher fertiliser application rates has a (small) climate mitigation effect. Higher N_2O emissions due to higher N applications are offset by the increase in yield, so emissions per kilogramme of output decrease. GHG emissions per kilogramme of cereals have been shown to decrease by about 160 kg N per ha (Guo et al. 2022). N amounts beyond 160 kg N per ha cause emissions to rise and are thus likely detrimental to climate protection. The 160 kg N per ha is taken from a global meta-study (Guo et al. 2022); specific soil and climate conditions in Kosovo may lead to slightly different optimal N inputs that balance emissions with yields. Furthermore, higher yields may result in more crop residues, which, if managed sustainably, can contribute to the accumulation of more organic matter in the soil and thus provide further climate protection (Halvorson, Reule and Follett 1999). However, we have not studied this effect here due to the lack of soil and soil management data.

A more efficient manure storage and application to fields resulted in small GHG savings in the simulations. When manure is stored in a more climate-friendly manner and applied daily to crop fields (the WAM scenario), then 5.2 Gg CO_2eq are saved relative to the baseline, which is negligible compared to the other mitigation measures that were assessed. However, the Tier 1 approach is particularly prone to errors in calculating manure management emissions, and the results would need to be verified with better soil and agronomic data, as well as more sophisticated methods, such as Tier 2 or Tier 3. Additionally, the application of manure can facilitate the accumulation of organic matter in the soil and improve the protection of the soil, but we have not considered these factors.

Figure 5: GHG emissions and removals from agriculture



Source: Own calculations.

5. Discussion and Policy Implications

The AFOLU sector constitutes a small GHG sink of 51 Gg CO_2eq in the baseline year 2021. However, this sink will substantially increase to 407 Gg CO_2eq if existing policy measures (WEM) are successfully implemented until 2030.

Large and productive forests are an important sink of greenhouse gases and offset the emissions generated by livestock and crop production. Our results show that forests can store much larger amounts of carbon if current extremely high levels of firewood extraction are reduced. Kosovo is among the countries with the highest rates of illegal timber extraction in Europe. However, the fact that forests are a small sink for greenhouse gases is due to the high productivity of forests. The WEM scenario shows that it is likely that forests will capture higher amounts of C in the future because it is expected that illegal wood extraction will decrease. Future pressure on the extraction of forest resources for firewood is arguably decreasing because both the expected shrinkage of the rural population and a partial shift to alternative sources will reduce extraction rates.

Key bottlenecks in developing the forestry sector to improve its C sink include budgetary constraints for forest development, a decline in enrolments in forest education, a lack of technical skills, and the absence of any research related to forests (there exists only one professor of forestry in the entire country). Silvicultural experts are rare, and therefore implementing silvicultural improvements in forestry remains a challenge. Furthermore, there are few tree nurseries that provide the seedlings necessary for enrichment plantings in degraded forests (personal communication). In sum, human resources are absolutely needed to support regeneration and implement silvicultural measures to increase forest quality and biomass.

Policy measures such as promoting efficient cooking and heating stoves, stopping illegal and thus uncontrolled firewood procurement, and purchasing climate-friendly fuels (e.g., liquid natural gas, LPG, and pellets) can reduce demand for firewood, and thus firewood extraction. Furthermore, winters will tend to become increasingly warmer under climate change in the region (Müller and Hofmann 2022), which will tend to reduce the demand for firewood for heating, but we have not considered this factor in this study.

Climate mitigation in the AFOLU sector can also be achieved through approaches that we have not considered, mainly due to lack of data. An important and promising strategy, which we were unable to consider, is conservation agriculture (CA), which summarises management strategies that have the primary goal of increasing the amount of organic matter in the soil. This can be achieved through no or minimal tillage, complex crop rotations, and intercropping (Reicosky 2021). Measures that increase the humus content of soils sequester additional carbon and increase the water storage capacity, which means that CA can be beneficial both for climate mitigation and for climate adaptation.

Organic farming can also be beneficial for climate protection. Reduced use of plant protection and mineral fertilisers in combination with a biological cycle system in which residual materials are used efficiently (e.g., organic amendments as fertiliser) can lead to lower GHG emissions through fewer emissions in the production process and higher C storage in soils. However, it must be examined on a case-by-case basis to determine to what extent the lower yields typically attained in organic farming systems are fully compensated for by the emissions reductions and additional sinks.

We have implemented the reduction of the number of cattle by 10% and 20% in the WEM and WAM scenarios, respectively. Clearly, reductions in livestock herds reduce emissions and reduce the demand for agricultural land to grow feed. However, it is important to note that domestic reduction in livestock numbers does not reduce global emissions when these reductions are not accompanied by a reduction in domestic consumption. Without lower consumption, domestic reduction in livestock would lead to higher imports of livestock products and simply displace emissions to other places. More generally, the low self-sufficiency of Kosovo in producing some key agricultural products, such as wheat and beef, implies that substantial emissions are imported from elsewhere. As the approach taken here is based on domestic production within the AFOLU sector, we do not account for these. A consumption-based accounting of the GHG emissions from the AFOLU sector would arguably have increased the emissions of Kosovo.

Some of the measures with high emission reduction potential may constitute low hanging fruits that can be achieved with small additional efforts and at low costs. Investments in human resources in the forestry sector will facilitate silvicultural measures that can improve the C sink of forests. Several promising mitigation pathways have co-benefits for people and nature beyond emission reductions; these pathways could constitute preferred policy options. For example, reducing indoor firewood consumption through more efficient stoves or alternative cleaner energy sources not only reduces emissions, but also prevents indoor air pollution and frees rural labour for other activities. Improving vegetation cover in crop fields, such as through efficient residue management, reduced tillage operations, and wide crop rotations, improves C storage in soils and vegetation, but can, at the same time, improve soil fertility, reduce erosion, improve water retention in soils, and thus improve crop yields in the medium to long run.

In the absence of quantitative targets for the WAM scenario, we have applied subjective judgments based on existing literature, interviews with local experts, and consultations with other sector experts to develop suggestions for additional emission reductions. The WAM scenario, in particular, focusses on the measures that have a large impact on additional emission reductions or enhancement of sinks. We cannot verify the feasibility of the WEM and WAM scenarios implemented. These give, however, the direction of expected changes under prescribed policies and thus should serve to guide policy formulation that is geared towards GHG emission reductions or the enhancement of sinks.

6. Literature

Guo, C., X. Liu & X. He (2022) A global meta-analysis of crop yield and agricultural greenhouse gas emissions under nitrogen fertilizer application. *Science of The Total Environment,* 831**,** 154982. https://doi.org/10.1016/j.scitotenv.2022.154982

Halvorson, A. D., C. A. Reule & R. F. Follett (1999) Nitrogen Fertilization Effects on Soil Carbon and Nitrogen in a Dryland Cropping System. *Soil Science Society of America Journal,* 63**,** 912-917. https://doi.org/10.2136/sssaj1999.634912x

IPCC. 2006. 2006 IPCC Guidelines for National Greenhouse Gas Inventories. In *Prepared by the National Greenhouse Gas Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (eds). Published: IGES, Japan.*

---. 2022. *IPCC Inventory Software - User Manual Version 2.83*. https://www.ipcc-nggip.iges.or.jp/software/ (last accessed: March 13, 2023).

KAS. 2023. *Agricultural Household Surveys*. Kosovo Agency of Statistics. https://askdata.rks-gov.net/pxweb/en/ASKdata/ (last accessed: April 20, 2023).

KEPA. 2021. Annual report on the state of the environment for 2020. Pristina: Kosovo Environmental Protection Agency.

Khabarov, N., A. Krasovskii, M. Obersteiner, R. Swart, A. Dosio, J. San-Miguel-Ayanz, T. Durrant, A. Camia & M. Migliavacca (2016) Forest fires and adaptation options in Europe. *Regional Environmental Change,* 16**,** 21-30. 10.1007/s10113-014-0621-0

Krajnc, N., R. Pisek, A. English & M. Waschak. 2015. *Wood Biomass Sector in Kosovo Woodfuel Integrated Supply/Demand Overview Mapping (WISDOM)*. Pristina: Food and Agriculture Organization of the United Nations (FAO).

MAFRD. 2016. National Afforestation and Reforestation Program 2018 - 2027. Pristina: Ministry of Agriculture, Forestry and Rural Development.

---. 2021a. *Kosovo Irrigation Master Plan*. https://ardp-ks.org/kosovo-irrigation-master-plan/ (last accessed: April 22, 2023).

---. 2021b. Policy and Strategy on Forestry Development in Kosovo 2022-2030. Pristina: Ministry of Agriculture, Forestry and Rural Development.

---. 2021c. Strategy for Agriculture and Rural Development 2022-2028. Pristina: Ministry of Agriculture, Forestry and Rural Development.

---. 2022. Green Report 2022. Pristina: Ministry of Agriculture, Forestry and Rural Development.

Müller, D. & M. Hofmann. 2022. Impacts of climate change on agriculture and recommendations for adaptation measures in the Western Balkans. GFA Consulting Group on behalf of the German Federal Ministry of Food and Agriculture (BMEL).

OECD. 2021. Kosovo profile. In *Competitiveness in South East Europe 2021: A Policy Outlook,* ed. OECD Publishing. Paris.

Regional Cooperation Council. 2020. *Sofia declaration of the Green Agenda for the Western Balkans*. https://www.rcc.int/docs/546/sofia-declaration-on-the-green-agenda-for-the-western-balkans-rn (last accessed: Aug. 10, 2022).

Reicosky, D. C. 2021. Carbon Management in Conservation Agriculture Systems. In *Regenerative Agriculture,* eds. D. Dent & B. Boincean, 33-45. Cham: Springer International Publishing.

Sauer, J., M. Gorton & S. Davidova (2019) What drives rural out-migration? Insights from Kosovo. *Post-Communist Economies,* 31**,** 200-217. 10.1080/14631377.2018.1506623

Tomter, S. M., E. Bergsaker, I. Muja, T. Dale & J. Kolstad. 2013. Kosovo National Forest Inventory 2012. Pristina.

UBA. 2019. Nitrogen surplus from agriculture has been excessive for 20 years. Dessau: Umweltbundesamt.

World Bank. 2023. *World Development Indicators*. The World Bank. http://databank.worldbank.org/data/reports.aspx (last accessed: March 10, 2023).

Appendix

Table A 1: Baseline data

Variable	Value	Unit	Source
No of households	373,084	1000 HH	https://askdata.rks-gov.net/pxweb/en/ASKdata/
No of households, rural	208,029	1000 HH	MAED; KAS
No of households, urban	165,055	1000 HH	MAED; KAS
No of persons	1,809	1000 heads	https://askdata.rks-gov.net/pxweb/en/ASKdata/
Arable land	188	1,000 ha	https://askdata.rks-gov.net/pxweb/en/ASKdata/
Meadows & pastures	217	1,000 ha	https://askdata.rks-gov.net/pxweb/en/ASKdata/
Cattle	261	1,000 heads	https://askdata.rks-gov.net/pxweb/en/ASKdata/
Sheep	211	1,000 heads	https://askdata.rks-gov.net/pxweb/en/ASKdata/
Goats	30	1,000 heads	https://askdata.rks-gov.net/pxweb/en/ASKdata/
Firewood consumption	8.00	m3/HH/yr	MAED; KAS
Area affected by fires	2,650	Ha	Green Report 2022
Annual increment	3.22	m3/ha	NFI
Cereal yields	4	t/ha	Green Report 2022
Mineral fertilizer	42	kg N/ha/yr	own estimation, based on import numbers
Cropland area	188	1,000 ha	KAS Ag HH survey (Green Report)
Grassland area	217	1,000 ha	KAS Ag HH survey (Green Report)
Forest area	481	1,000 ha	KAS Ag HH survey (Green Report)
Residue management	20	%	% burned residues
Annual wood removal	1,862,000	m3/yr	Projection by R. Stubbe based on MAED

Table A 2: Enhancement of forest resources

Forest Dimension	Enhancement of forest resources
Sector	Forestry
Type of Instrument	Regulatory; Financial
Title of PaM	Enhancement of forest resources
(Coding)	(G-A1)
Timeframe	2022-2030
Legal basis and planning documents	
Actions taken to date	To be discussed
Main Objective of PaM	**Main objective:** Enhancement of forest resources Specific objective 1: Entire public forest area is administered with management plans; 2: Improve of forests through silviculture measures.
Results to be achieved	1. Increase of forest area by 1% in 2024 and 3% in 2030, from the baseline value of 481 000 ha of forests. 2. Increase of timber volume by 5,000,000 m3 in 2024 and 15,000,000 m3 in 2030, from the baseline value of 42 000 000 m3. 3. Forested areas covered by long –term management by 90% in 2024 and 100% in 2023. The baseline value is 82%. 4. Forest areas covered by multi-purpose integrated forest management 10,000 ha in 2024 (2 pilot sites) and 20,000 ha by 2030 (5 pilot sites), baseline value 0. 5. Area of even-aged and mixed forest achieved through silviculture treatment by 1400 ha in 2024 and 12,000 ha by 2023, baseline value 400 ha. 6. Area in ha of converted forests from coppice forests to high forests and support of the future trees by 600 ha in 2024 and 3000 ha by 2030, baseline value 0.
Measures to be implemented	Alignment of the forestry sector legislation with the EU Acquis. Forested areas covered by long –term management plans. Forest areas covered by multi-purpose integrated forest management plans in five pilot sites. Forest and forest land area inventoried. Regulation of titled holders and owners of public forests and their registration in the cadastre. Identification and registration of usurpations of forests and forest lands, as well as legal property disputes. Registration of forest lands by function. Increase (expansion) of forest areas.
Budget (source of budgeting)	Planned budget in 2024 is 1.5 Mil. Euros. Source: Budget of Kosovo and Donors.
Implem. entity (monitoring entity)	MAFRD, KFA, MPMS, PPP, donors, and community.

Table A 3: Protection of forest resources

Forest Dimension	Protection of forest resources
Sector	Forestry
Type of Instrument	Regulatory; Financial
Title of PaM	Protection of forest resources
(Coding)	(G-A1)
Timeframe	2022-2030
Legal basis and planning documents	Forestry Strategy 2022-2030.
Main Objective of PaM	Protection of forest resources
Results to be achieved	1. Reduction of illegal logging by 30% in 2024 and 70% in 2030, baseline value 0.9 million m3. 2. Increase of consolidated forest areas by 10% in 2024 and 30% in 2030, baseline value 0. 3. Reduction of the forest areas endangered by fires. By 50% in 2024 and 80% in 2030, baseline value 26,000 ha.
Measures to be implemented	Protection of forest resources through reduction of illegal logging, consolidation of forest lands, protection and monitoring of forests health, forest biodiversity conservation, and protection of forests from fires.
Budget (source of budgeting)	Planned budget in 2024 is 239,730.00 Euros. Source: Budget of Kosovo and Donors.
Implem. entity (monitoring entity)	MAFRD, KFA, MESTI, JICA, Donors.

Table A 4: Sustainable and multipurpose use of forest resources

Forest Dimension	Sustainable and multipurpose use of forest resources
Sector	Forestry
Type of Instrument	Regulatory; Financial
Title of PaM	Sustainable and multipurpose use of forest resources
(Coding)	(G-A1)
Timeframe	2022-2030
Legal basis and planning documents	Forestry Strategy 2022-2030.
Main Objective of PaM	Sustainable and multipurpose use of forest resources
Results to be achieved	1. Implementation of long-term management plans by 60% in 2024 and 85% in 2030, baseline value 40%. 2. Increase of legal annual logging by 50% in 2024 and 70% in 2030, baseline value < 20% in 2021. 3. Management of forests according to European sustainable management criteria and indicators by 20% in 2024 and 100% in 2030, baseline value 0%. 4. Sustainable development of ecotourism by 30% in 2024 and 80% in 2030, baseline value 0%.
Measures to be implemented	Simplify technical and administrative procedures for forest use; Regulate the issue of long-term logging permits; Define national sustainable forest management criteria and indicators; Capacity building of NWFP collectors and operators; Define potential areas for ecotourism and digitize and mark ecotourism paths.
Budget (source of budgeting)	Planned budget in 2024 is 450,000.00 Euros. Source: Budget of Kosovo and Donors.
Implem. Entity (Monitoring Entity)	MAFRD, KFA, MESTI, Donors.

Table A 5: Policies related to agriculture GHG emissions

Energy Dimension	1. Decarbonisation
	1.1. GHG emissions and removals
Sector	Agriculture
Type of Instrument	Regulatory; Financial
Title of PaM	Agri environment and climate schemes (local breeds, organic farming, extensive grassland management)
(Coding)	(G-A1)
Timeframe	2022-2028
Legal basis and planning documents	Law No. 03/L-098 ON AGRICULTURE AND RURAL DEVELOPMENT. Strategy for Agriculture and Rural Development 2022-2028. Action Plan of SARD 2022-2028.
Main Objective of PaM	**Strategic Objective 2:** Sustainable management of natural resources (land, forests, and water). **Specific objective 2.1:** Support in mitigation and in adaptation with climatic changes, like use of renewable energy.
Results to be achieved	GHG emissions from agriculture 6% in 2019, target value in 2024 <6% and <5% 2028. Maintaining a low level of GS emissions from agriculture.
Measures to be implemented	1. Introduce good agricultural and environmental practices aimed at improving carbon sequestration (for example, not burning incinerators). 2. Prioritize grants for farmers with investments in renewable energy.3. Afforestation of opening areas. 4. Preparing of management plans
Budget (source of budgeting)	Planned budget: 570,000 Euros in 2022; 570,000 Euros in 2023; 570,000 Euros in 2024. Source: 1. Budget of Kosovo KP: 40400 – PM40400/DSHKT:17. 2. Budget KP:40700 –PM. 3&4. Budget KP 40300-KP.
Implem. Entity (Monitoring Entity)	MAFRD & ADA

Energy Dimension	1. Decarbonisation
	1.1. GHG emissions and removals
Sector	Agriculture
Type of Instrument	Regulatory; Financial
Title of PaM	Agri environment and climate schemes (local breeds, organic farming, extensive grassland management)
(Coding)	(G-A1)
Timeframe	2022-2028
Legal basis and planning documents	Law No. 03/L-098 ON AGRICULTURE AND RURAL DEVELOPMENT. Strategy for Agriculture and Rural Development 2022-2028. Action Plan of SARD 2022-2028.
Actions taken to date	To be discussed
Main Objective of PaM	**Strategic Objective 2:** Sustainable management of natural resources (land, forests, and water). **Specific objective 2.2:** Promoting sustainable and efficient resource management (land, water, air).
Results to be achieved	270 farms and agro-industrial enterprises with fertilizer depots and waste and waste management units.
Measures to be implemented	Measure 1: Grants for investments in physical assets of agricultural holdings. Prioritization of grants for farmers with investments in fertilizer depots for manure management.
Budget (source of budgeting)	Annual /part of the budget for Measure 1 (Grants for investments in physical assets of agricultural holdings). Source: Budget KP: 40700-SB.
Implem. Entity (Monitoring Entity)	MAFRD & ADA

Table A 6: Policies related to biodiversity protection

Energy Dimension	1. Decarbonisation
	1.1. GHG emissions and removals
Sector	Agriculture
Type of Instrument	Regulatory; Financial
Title of PaM	Agri-environmental schemes for biodiversity protection.
(Coding)	(G-A1)
Timeframe	2022-2028
Legal basis and planning documents	Law No. 03/L-098 ON AGRICULTURE AND RURAL DEVELOPMENT. Strategy for Agriculture and Rural Development 2022-2028. Action Plan of SARD 2022-2028.
Actions taken to date	To be discussed
Main Objective of PaM	**Strategic Objective 2:** Sustainable management of natural resources (land, forests, and water). **Specific Objective 2.3:** Biodiversity protection, improvement of ecosystem services and conservation of habitats and landscapes / nature.
Results to be achieved	By 2024, 100 ha according to the agro – environmental schemes for the protection of biodiversity. By 2028, 500 ha according to the agro – environmental schemes for the protection of biodiversity. Maintenance of high natural biodiversity of pastures.
Measures to be implemented	1. Extensive pasture management for high biodiversity lands in areas with proven biodiversity values, such as protected areas. 2. Preparation of guidelines for farmers and pasture users for the use and management of value-added pastures.
Budget (source of budgeting)	500,000 Euros. Source: 1. Donors and 2. Budget KP: 40400-PM.
Implem. Entity (Monitoring Entity)	MAFRD / Advisory Services

Table A 7: Policies related to organic farming

Energy Dimension	1. Decarbonisation
	1.1. GHG emissions and removals
Sector	Agriculture
Modelling Scenario Considered	
Type of Instrument	Regulatory; Financial
Title of PaM	Agri-environmental schemes for biodiversity protection.
(Coding)	(G-A1)
Timeframe	2022-2028
Legal basis and planning documents	Law No. 03/L-098 ON AGRICULTURE AND RURAL DEVELOPMENT. Strategy for Agriculture and Rural Development (SARD) 2022-2028. Action Plan of SARD 2022-2028.
Actions taken to date	To be discussed
Main Objective of PaM	**Strategic Objective 3 -** Development of businesses in rural areas and increase of employment and social infrastructure. **Specific Objective 3.2:** Improve societal requirements for food and health, including safe, nutritious and sustainable food, reduction of food waste, and animal welfare.
Results to be achieved	21 farmers will receive funding each year for the adaption of organic farming practices.
Measures to be implemented	Organic farming -subsidizing / compensating for farmers who follow the rules of organic farming, as their production is usually lower against the ban on chemical fertilizers and pesticides.
Budget (source of budgeting)	400,000 Euros (time frame 2022-24). Source: Budget KP: 40100-SB.
Implem. Entity (Monitoring Entity)	MAFRD & ADA
Relation with other dimensions (if any)	

Table A 8: Fractions of total annual nitrogen excretion managed in manure management systems for each species livestock category in Kosovo (source: KEPA)

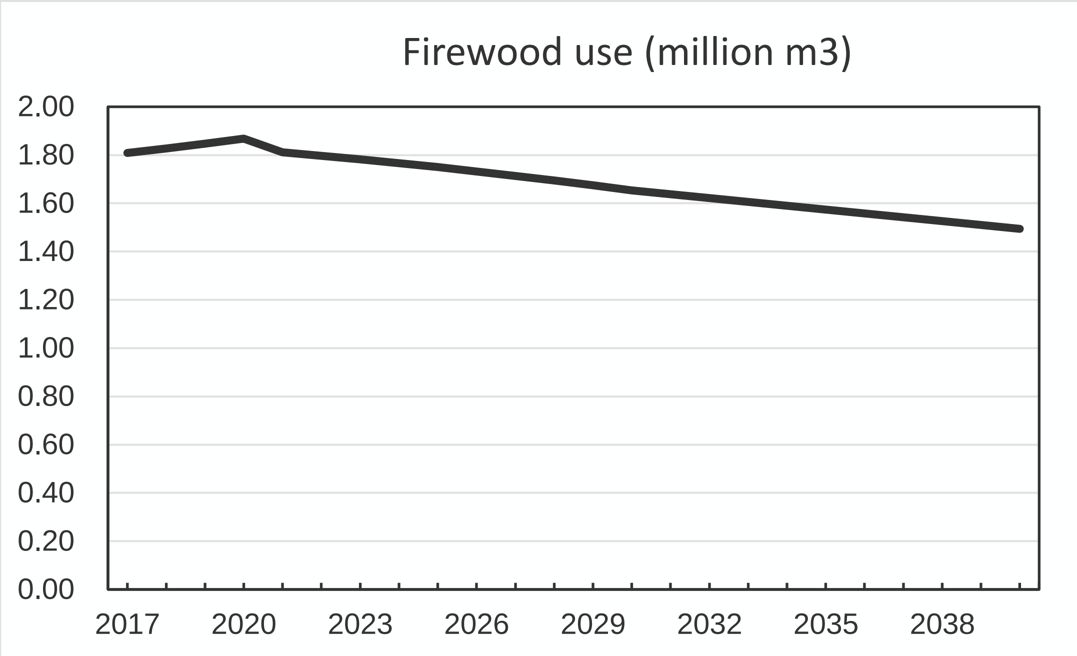
Livestock type	Fraction of Manure Nitrogen (%)				
	Pasture range and paddock	Daily spread	Solid storage and dry lot	Liquid/Slurry system	Other systems
Dairy cows	13%	68%	1%	18%	0 %
Other Cattle	8%	52%	1%	39%	0%
Goats	90%	0	10%	0	0%
Sheep	75%	0	25%	0	0%
Poultry	2%	0	28%	0	70%
Swine	30%	0	40%	30%	0%
Horses	92%	0	8%	0	0%

Table A 9: WEM and WAM projections

Sector	Emission category	Variable	Base (2021)	WEM (2030)	WAM (2030)
		Emissions (Gg CO2eq)			
3.A - Livestock	3.A.1 - Enteric Fermentation (Gg CO2 eq.)	Cattle	375,2	282,1	188,0
		Sheep/Goat	25,3	17,7	11,8
		Horses	0,7	0,8	0,5
		Swine	1,0	0,8	0,5
		Total 3.A.1	**402,2**	**301,3**	**200,9**
	3.A.2 - Manure Management (Gg CO2 eq.)	Cattle	49,0	38,3	38,3
		Sheep	1,9	1,9	1,9
		Horses	0,0	0,0	0,0
		Swine	4,8	4,5	4,5
		Poultry	6,7	5,3	5,3
		Total 3.A.2	**62,4**	**50,0**	**50,0**
		Total 3.A - Livestock	**464,6**	**351,3**	**250,9**
3.B-Land	3.B.1.a - Forest land Remaining Forest land	Biomass increase	2925,9	2925,9	3216,7
		Biomass removal (firewood)	1954,9	1785,6	1619,2
		Biomass removal (Fires)	168,2	126,9	63,5
		Biomass change 3.B	**802,7**	**1013,3**	**1534,0**
3.C.1.a - Aggregate sources N2O	Emissions from burning in Forest Land	Methane	8,8	6,6	3,3
		Nitrous Oxide	1,6	1,2	0,6
		Total 3.C.1.a	10,4		
3.C.1.b	Emissions from burning in cropland	Methane	12,2	6,1	3,1
		Nitrous Oxide	4,7	2,3	1,2
		Total 3.C.1.b	16,9		
		Total 3.C.1	**37,7**	**16,3**	**8,1**
3.C.4	Direct N2O Emissions from managed soils	Synthetic N applied	56,8	34,6	22,1
		Organic N applied	64,8	72,4	
		N in crop residues	40,9	49,0	57,6

3.C.5	Indirect N2O emissions from managed soils	N2O Atmospheric Deposition	18,6	15,2	
		N2O leaching/runoff	36,5	27,2	
3.C.6	Indirect N2O emissions from manure management	Volatilisation	21,4	19,4	
		Leaching & runoff	20,8	20,9	
		Total 3.C. 4-6	**259,7**	**238,7**	
		Total AFOLU	**-40,7**	**-407,0**	**-1274,9**

Figure A 10: Firewood use (million m³)



Source: Projections by R. Stubbe with data from MAED