Carbon Emissions Trading Potential of Turkiye's Forest

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The current study emphasizes the inherent shortcomings of laws and policy approaches that are based on the premise that by increasing wood production, much more emission credits can be achieved by using wood in alternative uses. The article aims to exploit the financing of emission reductions, discuss how carbon sinks held in forest resources can be activated, traded, and financed, and explain how Turkiye's forest carbon potential can be exploited. To make a comparative analysis of the situation of Turkiye at global level, Russian's potential for carbon sequestration and its trade have been dealt with as a comparison by following quantitative research methodology. In this research, the calculation method has been used to determine the number of houses that are likely to be built in rural areas using wood materials, *e.g.*, the construction of 100,000 houses with a construction area of 100 m^2 per year. Consequently, the forest carbon generated by alternative scenarios contributes positively to the emission balance sheet, as well as climate change mitigation through carbon emission trade despite all legal and technical constraints. Although both countries have similar shortcomings of obtaining carbon credits and its trade, of course Russia has a promising situation in comparison with Turkiye with respect to the amount of carbon sequestered and the likelihood of its trade potential at global level.

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INTRODUCTION

Climate change is a significant obstacle affecting economic, social, and environmental policies. Such an important global problem forces all countries to compromise and to take various measures (Turker and Aydın 2022). One of them is the tendency towards global agreements on joint measures such as the Sustainable Development Goals, the UN Framework Convention on Climate Change, and the Paris Agreement. To improve bilateral cooperation, Turkiye actively participates in regional and international studies. In addition, it tries to play an active role in solving the problem by harmonizing development goals.

The desire to have increased living standards and to reach a healthier environment for many years and the demand to improve the general welfare of society has been boosted. The drive for the highest level of comfort leads to the consumption of environmental resources and consequent pollution and degradation. The resulting carbon emissions and climate change bring about various climate-related environmental disasters (Uyar and Cengiz 2011). Global efforts to control the negative effects of climate change continue to be developed. Among these, countries need national-international legal arrangements for participation in these international mechanisms. Because combating climate change requires a strong legal foundation. As a result, nearly all nations have passed laws addressing climate change (Eskander *et al.* 2021).

Internationally, there are some obligations to keep carbon emissions, which are among the causes of climate change, at a certain level. At the international level, many agreements, provisioning the importance of forest resources, have been enacted to combat global climate change and adapt to its impacts. The Vienna Convention, the Montreal Convention, the UNFCCC, the Kyoto Protocol, and the Paris Convention are the most important of these. The forest ecosystem plays a crucial role in all of these international initiatives to combat climate change as a carbon sink (Jandl *et al*. 2007; Canadell and Raupach 2008; Smith *et al.* 2014; Karal and Gencay 2020) and has an organic carbon storage rate of 76% to 78% (Sivrikaya and Bozali 2012). Some international accords have mostly acknowledged the value of forests in storing carbon. The Paris Agreement's Article 5 places a strong emphasis on the need to preserve and expand forest sinks and reserves. The parties should make efforts to reduce emissions, and sustainable forest management should be stressed, it was said in the agreement. In this regard, nations create inventories of greenhouse gases and determine the amount of carbon sequestered by land use (Tolunay and Çömez 2007). In reality, obligations have been placed on the party countries in terms of adaptation to climate change and mitigating its consequences through the UNFCCC, which is noted as a crucial step in the response to the climate problem. Additionally, several mechanisms were created in the conferences of the parties and the Kyoto Protocol, which was signed within the parameters of the convention (Yetiş and Özden 2020). These instruments include:

- National measures to be taken in related sectors
- Kyoto protocol flexibility mechanisms; clean development mechanism (project-based), joint ımplementation mechanism (project-based), International Emissions (Carbon) Trading (market-based)
- International funds; World Bank, Global Environment Facility (GEF), and other international funds
- Bilateral and regional cooperation
- Legal instruments (taxes)
- Incentive mechanisms
- National emissions (carbon) trading systems
- Voluntary carbon markets (Ecer 2010)

Project-based and market-based flexibility mechanisms are separated (Binboga 2017). Effective carbon pricing is one of the tools used in the market-based approach and is thought to be crucial for achieving emission reductions (Birol and Bilgici 2021). Carbon tax and carbon trading are the two main pricing mechanisms utilized in this process, and they are also two of the most popular market-based economic instruments (Aliusta *et al.* 2016; World Bank 2020). Carbon tax is a type of tax, levied on the carbon emissions of fossil fuels, used to reduce carbon emissions (Dağlı 2019). The first of these two techniques, carbon trading, is founded on the idea that countries' lowered greenhouse gas emissions are verified and exchangeable on carbon markets (Yılmaz 2019; Ubay and Bilgici 2021). Markets that are both required and voluntary are used for carbon trading.

Project-based and market-based voluntary carbon markets, such as the Chicago Climate Exchange (CCX), are examples of voluntary systems (Ülgen and Güneş 2016).

The two parties to this exchange in carbon trading are the buyer who generates emissions and the seller who decreases emissions. The voluntary carbon market is built on this method, and this market transaction between buyers and sellers of carbon credits is described as “carbon offsetting” (Peker and Altınışık 2011). On the other hand, the carbon credits acquired through the initiative are traded on the market like goods and commodities. According to Elitaş and Çetin (2011), the carbon trading system based on forest carbon that is the focus of this study is a system that connects buyers and sellers. It is possible to use forests to generate voluntary carbon credits (Oral 2020). Forest carbon stored in sinks should be verified and utilized to reduce carbon emissions as part of the fight against global warming. However, some requirements including additionality, measurability, monitoring, and permanence must be satisfied to receive certified carbon credits through the project in the voluntary market. Innovative strategies are required for the purchase of forest carbon credits due to the restrictions and ambiguities in national legislation surrounding these requirements. Obtaining forest carbon credits through alternate uses of wood is one of the ways to gain certified forest carbon credits on the market.

The study is based on the subject of how certification of forest carbon gained through alternate applications of forest carbon can boost the emission trading potential. The methods of emission reduction through the use of wood material in residential buildings in rural regions and therefore collecting C credits were examined to offer alternatives for the evaluation of the emission trading potential. The volume, cost, and trade potential of the total amount of emission reduction were evaluated using the scenario of rural construction using wood raw material instead of concrete (according to the scenario of 100,000 dwellings per year in a 100 m^2 construction area). Additionally, using Turkiye as an example, the beneficial impact of afforestation carbon in the forest area where the wood will be acquired on the calculation of carbon sequestration is examined. To start, the worldwide outlook on the possibilities for carbon trading and Turkiye's forest carbon inventory is highlighted. The study then makes a comparison between Turkiye and Russia to clarify where Turkiye’s forest carbon system stands in comparison to other forests or other comparable carbon sequestration systems. Then, it will be determined whether switching to wood material instead of raw materials like iron and steel, concrete, *etc*. will result in more carbon credits being collected. These evaluations will help the world's nations meet their legal obligations to reduce carbon emissions. Additionally, this contribution will increase the number of emission credits and profit that may be made while also increasing carbon sequestration.

EXPERIMENTAL

This is a quantitative and comparative study. The research methodology followed first presents the theoretical structure and conceptual discussion, and then supports the outcomes of the study put forward by using the data obtained through the literature review. Therefore, the quantitative analysis approach has been followed using a comparison between Turkiye and Russia. The calculation method first determines the number of houses that are likely to be built in rural areas using wood materials, which are envisioned as the construction of 100,000 houses with a construction area of 100 m^2 per year. Each 100 m^2 of such a construction, the amount of iron and steel used, and the amount of emission emitted were calculated. Similarly, for every 100 m^2 of construction, the emission amount of concrete and cement required was calculated. The total amount of emissions for each 100 m^2 of reinforced concrete housing construction was calculated. The financial size of the total emission reduction was calculated by finding the metric ton carbon market price of this amount, assuming that this amount of emissions would be avoided if the wood was used as an alternative.

Because an additional annual allowable cut (AAC) (m^3/year) period is needed to obtain this amount of wood material from forest resources, this additional decreasing amount must be fully carbon certified and recorded as a carbon capture. Besides, assuming that this construction wood material could remain in construction for 100 years without decaying or otherwise producing emissions, reforestation in the forest area where this amount of m^3 of wood obtained was included in the scenario. The carbon sequestration is also included in the calculation positively. Therefore, the carbon credit through emission reduction as a result of abandonment of reinforced concrete construction needs to be calculated in the scenario, as wood material is obtained from forests. Hence, carbon credit due to the reforestation of this cut forest area, which will be obtained/sequestrated by linking the afforestation carbon to the certificate, are also taken into account. Thus, by multiplying the resulting carbon credit with the market price of a metric ton of carbon, the resulting carbon credit and trade potential are calculated.

Global Forest Assessment and Forest Carbon Inventory

Approximately 54% of the world's forest areas are found in five nations: the Russian Federation, Brazil, Canada, the United States of America, and China (FAO 2020). The entire global forest carbon store is predicted to be 662 Gt (163 tons per hectare), according to The Global Forest Resources Assessment (FRA) 2020. Of this, 68.0 Gt is made up of dead wood and trash, and 295 Gt of which is living biomass. While they have drastically dropped in South America, Oceania, West Africa, Central Africa, and North Africa, carbon stores in forest biomass have increased in East Asia, West and Central Asia, Europe, and North America. Global carbon stock levels are falling (FAO 2020); Table 1).

Table 1. Total Forest Carbon Stock, Bye and Subregion, 1990-2020

Region/Sub Region	**Forest Carbon Stock (million tonnes)**			
	1990	**2000**	**2010**	**2020**
Eastern and Southern Africa	30 932	29 642	27 978	26 250
Northern Africa	2 338	2 242	2 190	2 090
Western and Central Africa	61 005	58 253	55 745	52 546
Total Africa	94 274	90 137	85 913	80 886
East Asia	27 110	30 261	33 908	37 907
Southern and South-east Asia	45 804	43 792	43 071	41 468
Western and Central Asia	4 180	4 511	4 959	5 358
Total Asia	77 093	78 564	81 938	84 733
Europe and Russian Federation	31 625	34 260	36 833	39 192
Total Europe	158 744	162 457	168 069	172 442
Caribbean	1 552	1 783	1 977	2 098
Central America	4 988	4 617	4 270	4 069
North America	136 644	137 730	139 324	139 951
Total North and Central America	143 184	144 131	145 572	146 118
Total Oceania	33 338	33 111	33 077	33 063
Total South America	161 765	154 917	147 917	144 846
WORLD	668 399	663 316	662 485	662 088

FAO. 2020. Global Forest Resources Assessment 2020; https://doi.org/10.4060/ca9825en

The research takes into account the forest and carbon system of the Russian Federation to put Turkiye's forest carbon system in comparison with other forest carbon sequestration systems. More than one-fifth of the world's forested land is found in Russia (Nordregio 2023). The gross value added of Russia's forestry sector in 2019 was 0.74%, which is low when compared to the indicators of comparable nations despite the country having a fairly big forest area. For instance, it can account for up to 5% of the GDP in Sweden and Finland. Predatory logging, forest fires, bad management, and inadequate protection of the woods, which are dispersed across very broad areas, are to blame for this. As local producers switch to roundwood and timber, the export potential of Russia's forest wealth is significantly impacted (Mediawood 2023). To improve the forest sector in terms of the wood business, Russia, which has 15% of its forest cover lost, needs to pay more attention to forestry (Woodru 2023).

Russian Forest Carbon Inventory

In Russia, the National Forest Inventory System debuted in 2007 (Duel 2021). According to the State Forest Inventory, there are 10.8 billion tons of carbon reserves in the forests of the Siberian Federal District, 13.8 billion tons in the forests of the North-Western Federal District, and 5.8 billion tons in the forests of the Siberian Federal District (Forestcomplex 2021). The consumption and export of fossil fuels are the main components of Russia's energy strategy through 2035, which was adopted in 2021 and is in conflict with the Paris Agreement's 1.5 °C temperature reduction goal. The LULUCF sector has been a reliable emission sink since the 1990s, with its greatest level in 2010 (-720 $MtCO_2$). According to the data, it fell to -569 $MtCO_2$ in 2020, and, assuming the policies put in place are kept, it will fall to 246 $MtCO_2$ in 2030 (Lynn, 2023). The Russian Federation established a target of reaching net zero greenhouse gas emissions by 2060 in its long-term climate strategy (LTS) that was presented to the UNFCCC in September 2022 (Russian Federation 2021, 2022). However, due to "changing conditions" and "increasing challenges," the Ministry of Economic Development is revising its intentions for the strategy (TASS 2022). On the other hand, the emphasis has been on the trading system for both Russian and foreign investors to boost the competitiveness of the national carbon market. It is well known that an arrangement was signed with Gazprombank to make the system appealing. To do this, the main climate change organization in Russia, IGCE, has developed a set of Russian carbon methodologies that take into account the requirements of potential project developers for the carbon credit register. Due to this, the Russian National Commodity Exchange began trading carbon credits in late 2022, and Russian carbon credits soon began to trade for more than $15 (Lynn, 2023).

By shifting to green energy and enacting fossil fuel divestment laws, Russia, with its abundant natural resources and biomass resources, has the benefit of being a pioneer in the global carbon market (Safonov *et al.* 2022). However, given that Russian log output is anticipated to surpass 300 million m^3 in 2030, the nation is anticipated to implement regulations to foster the growth of wood businesses. To achieve this, it is advised to concentrate on the wooden housing construction business by encouraging domestic wood consumption (Petrov and Lobovikov 2012). In addition, it is anticipated that the Russian wood-building market will expand quickly in the future.

Russia is a signatory to both the Paris Agreement and the United Nations Framework Convention on Climate Change (UNFCCC). While the national emission reduction target (NDC) is thought to be inadequate, industries with high carbon footprints, such as those that produce metal, chemical fertilizer, cement, and other commodities, anticipate making the switch to zero carbon within the next 10 years. Additionally, Russia has a significant ability to mitigate costs at very low or even negative levels (Shigui 2023). In terms of carbon sequestration and the production of wood products, Russia's huge forests are crucial for emission reduction. Carbon emissions from forests have dropped from 750 to 620 $MtCO_2$ annually over the past 10 years.

By employing wooden homes and construction materials instead of conventional cement, concrete, steel, and plastic, it is envisioned that Russia will be able to minimize its greenhouse gas emissions. Additionally, carbon can be retained and sequestered in this manner, aiding in mitigation. By concentrating just on addressing the needs for wooden houses, the annual emission reduction potential is predicted to be 63 $MtCO_2$ (Leskinen *et al.* 2020). Although there is a great deal of potential for Russia to meet its international obligations and emission reduction goals, it must acquire new skills to do so. One of the government's top priorities appears to be the use of hydrogen production and forest carbon sinks for mitigation due to their low cost (Shigui 2023).

Turkiye Forest Asset and Forest Carbon Inventory

Turkish forest cover is 23,110,000 hectares, covering approximately 29.6% of the country's surface area. Within this area, the normally closed forest area constitutes 58.42% of the total forest area with 13,500,000 hectares, and the hollow closed forest area constitutes 41.58% of the total forest area with 9,610,000 hectares (GDF 2021). It is calculated that 1,990,000,000 tons of carbon is sequestered in Turkiye's forests and 43,360,000 tons of oxygen is produced in return (GDF 2020), (Fig. 1), 94.48% of the forests are managed as forests and 5.52% as coppice, the total tree wealth is approximately 1.72 billion m^3, and the increment, which is an indicator of the wood raw material yield power of forests, is 47.6 million m^3 (GDF 2021).

It would not be wrong to say that the main source of climate change is carbon dioxide emissions from human activities. Two-thirds of carbon dioxide emissions are caused by the burning of fossil fuels such as coal, oil, and natural gas, and one-third by deforestation and changes in land use in tropical regions (Vakur 2014).

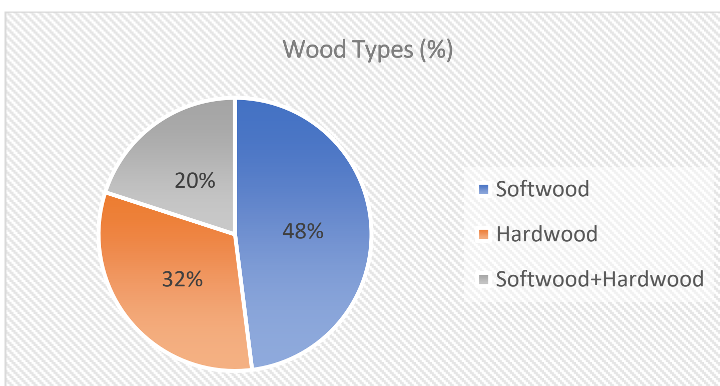

Fig. 1. Wood types in Turkiye (GDF 2020)

"As an Annex, I Party to the United Nations Framework Convention on Climate Change" (UNFCCC), Turkiye submits annual reports on greenhouse gas inventories. The latest greenhouse gas inventory notification includes national greenhouse gas emission/sequestration estimates for the period of 1990 to 2016. The emissions presented in this paper are those submitted to the UNFCCC Secretariat in 2018. The underlying factors of Turkiye's emission trends, reasons for the choice of methodologies, and a full description of the emission factors and parameters used to estimate emissions for the relevant sectors are provided in the National Inventory Report (NIR) and Common Reporting Format (CRF) tables (available at https://unfccc.int/process/transparency-and-reporting/reporting-andreview-under-the-convention/greenhouse-gas-inventories-annex-i-parties/national-inventory-submissions-2018). According to Turkiye's latest greenhouse gas inventory, total greenhouse gas emissions in 2016 were 496.1 Mt CO_2 equivalent (CO_2 equivalent) excluding the LULUCF sector, and 428.0 Mt CO_2 equivalent including LULUCF. Compared to 1990 levels, this represents an increase of 135.4 % (Table 3.1) (MEU 2018).

Land Use, Land Use Change, and Forestry in line with the IPCC Guidelines, Turkiye reports both greenhouse gas emissions and sequestration in the LULUCF sector and changes in different carbon pools, including above- and below-ground biomass, dead wood, litter, litter cover, and soil for each category. Carbon stock changes of harvested wood products and emissions from other sources are reported under this sector. The subcategories reported as sinks are forest area remaining as forest area, areas converted to forest area, cultivated areas remaining as cropland, and harvested wood products. The subcategories reported as emission sources are areas converted to cultivated land, meadow pasture areas remaining as meadow pasture, areas converted to meadow pasture, and areas converted to settlements. In 2016, the LULUCF sector acted as a CO_2 sink with a -68.1 Mt CO_2 equivalent. In 1990, it was 28.9 Mt a CO_2 equivalent (135.4% increase). Although emissions from the LULUCF sector accounted for 13.7% of Turkiye's total greenhouse gas emissions (excluding LULUCF) in both 1990 and 2016, its share is between 10.2 to 14.2% (MEU 2018).

The LULUCF sector has been a net sink in Turkiye throughout the reporting period, and the uptake has increased over time. Key factors of such an increment include sustainable forest management, afforestation, rehabilitation of degraded forests, afforestation on forestland and conversion of coppices on remaining forestland to productive forests on forestland, effective management of forest fires and conservation activities, conversion from annual crops and grasslands to perennial plantations, and conversion from annual crops to grasslands. In 2016, Turkiye had 22.57 M ha of forest area, compared to 20.57 M ha in 1990. This means that between 1990 and 2016, 2 M ha of land was converted to forestland. Afforestation activities are the main factor behind the increase in forestland. The National Action Plan for Afforestation and Erosion Control was launched especially in 2008 to increase Turkiye's forest area. Between 2008 and 2012, various forestry activities (afforestation, reforestation, rehabilitation, erosion control, *etc.*) were performed. Forest fires (uncontrollable fires) and dam constructions are the main cause of emissions from the LULUCF sector (MEU 2018).

On the other hand, one method to encourage the alternative use of wood is to gain carbon credits through afforestation. However, depending on the ownership and usage rights of the afforested land, the carbon pool, whether it makes a unique contribution, the operation duration, and whether it results in carbon leakage, different amounts of forest carbon are obtained by afforestation. Additionally, to respond to market demands and take into consideration international conventions, the Constitution, the Forestry Law, and afforestation rules need to be revised (Ülgen and Güneş 2016). However, due diligence must be taken about the property rights in the forest resource and the sustainability principles of the forest for such carbon trading to occur.

Calculation method and basic principles

The creation of forest carbon credits requires adherence to some basic principles. Voluntary carbon markets are established to voluntarily reduce and offset greenhouse gas emissions resulting from various activities of individuals, companies, and facilities within the scope of the social responsibility principle (MoEF 2008). Credits used in voluntary carbon markets are gained through the execution of initiatives that reduce greenhouse gas emissions and increase sinks in sectors such as energy, forestry, and transportation.

When asked about the contribution of voluntary carbon markets to climate change from 2005, when they were established, to 2018, it can be stated that the environmental impact of the efforts made to reduce the emission rate should not be underestimated. For example, it contributes more than 435.7 $MtCO_2$ e according to data. With the signing of the Paris agreement, the structure of the carbon market has started to undergo some changes. Studies are underway to develop a local carbon pricing structure and adapt it to the voluntary market. It is estimated that there will be a demand for 1.6 to 3.7 billion tons of carbon credits between 2021 and 2035. It is expected that some of this demand will be met through forestry projects in the voluntary market (Hamrick and Gallant 2017). In the carbon stock calculation and reporting process to be provided by carbon projects, the principles of Transparency, Accuracy, Consistency, Comparability, and Completeness should be taken into account. To obtain certified carbon credits in the voluntary market, projects must also meet certain criteria in their projects. Among these criteria, the following criteria must be met:

- Additionality,
- Measurable,
- Monitoring,
- Permanence,
- Real,
- Verifiable,
- Enforceable,
- Synchronous,
- Leakage,
- Co-benefits (Hernandez, 2020; Serengil, 2020)

Obtaining forest carbon credits from a forest carbon project also requires the existence of a legal system that guarantees carbon rights.

The amount of forest carbon sequestered in Turkiye's forest resources that can be traded is extremely limited. For fundamental reasons such as additionality, leakage, measurability, differences in forest definition, *etc.*, only a very small fraction of the total sequestered carbon can be subject to carbon certificates and thus the potential for emissions trading is extremely limited. On the contrary, increasing the use of wood material in alternative uses, increasing the use of end-product wood material for long periods, such as 100 years, and increasing its use in home construction in particular, will significantly increase the amount of forest carbon credit that can be traded.

Emission reduction scenarios

Not all carbon sequestered in Turkiye's forests is subject to carbon emissions trading. First, the amount of forest resources that meet criteria such as intrinsic value, no leakage, *etc.* is extremely limited, which further limits the ability to generate forest carbon emission credits, and this limitation is further compounded by both the duration of management and low productivity.

Second, increasing the production of wood from Turkiye's forests and using this wood for alternative uses would result in much more emission credits. While the first thing that comes to mind among these alternative sectors is to reduce the consumption of fossil fuels by producing biomass energy, it is a much more rational alternative scenario to consider the housing construction sector, which also offers the possibility of long-term (100 years on average) use of wood raw material.

Third, the housing sector and the construction sector are different from each other, even though their production and lifecycles are used in the same sense. Considering its utilization aspects, the housing sector is a component of the construction sector. The housing sector, which is labour-intensive and based on unskilled labour, has low import dependency. It has a triggering effect on other sectors. Besides, production activities in the housing sector are partly seasonal. Employment and production opportunities are therefore not sustainable (Karluk 2005). When looking at the housing construction sector in Türkiye, 131,848 residential building construction licenses have been issued as of 2016, which accounts for 202,321,341 m^2 of the construction area (Çınar 2018).

With respect to housing construction, it is rational to build houses with wood, especially in rural areas. Less carbon emissions and cost are two benefits of producing wood materials over reinforced concrete (Sathre and Gustavsson 2009). By revising their wood incentive policies, those nations that promote the widespread use of structural timber are promoting the sector's transformation (Table 2). To protect the environment and fight climate change, the construction industry must employ wood incentive programs on a global scale (Şişman and Balaban 2023).

In this study, in the residential construction sector in Turkiye, the amount of carbon emission was calculated for the carbon sequestered in forest resources in the case of housing construction with wooden materials where concrete and iron are not used for reinforced concrete construction. In this calculation, the reinforced concrete construction type and the construction area were taken as 100 m^2. If concrete and iron are used in this type of construction, carbon emissions were calculated, and if these materials are abandoned, *i.e.* if the wood is used, the following questions were considered: how much carbon will be sequestered, and based on this, how much forest carbon emissions will be generated.

In a 100 m^2 reinforced concrete building, the amount of concrete and steel used varies depending on the foundation and the project of the building (Korkmazhaber 2021). If raft foundation and curtain wall concrete are used, 13 tons of iron is used for a 100 m^2 house. If a building is to be built on the sub-base without a basement, an average of 7 tons of iron is used. If additional 2nd and 3rd floors are built on top of this floor, an additional 4 to 5 tons of iron is used on average. On the other hand, if we calculate how much iron will be used for a 100 m^2 house with a square meter calculation; 37 to 40 kg of iron per m^2 is used for the foundation of the construction; 32 to 34 kg of iron per m^2 for hollow slab flooring; 25 to 27 kg of iron per m^2 for a normal floor; 22 to 23 kg of iron per m^2 if the roof is to be concreted directly (Korkmazhaber 2021).

Table 2. Wood Incentive Policies in the World

Country	Year	Legal Initiatives	Type	Scope
Finland	1997	Time for wood	Program	National
	2004	Land use planning incentives for wooden construction	Act	National
	2011	National Wood Construction Programme (2011–2015)	Program	National
	2016	The Wood Building Programme	Program	National
Sweden	1997	Legislative Amendment	Act	National
	1997	Wood, Construction and Furniture Program	Program	National
	2006	National Wooden Building Strat.	Program/Strategy	Local
	2012	Wood City 2012	Program/Strategy	Local
Canada	2009	Wood First Act (British Columbia)	Act	Local
	2009	Strategy for the Use of Wood for Construction (Québec)	Act	Local
	2012	Wood First (Ontario)	Act	Local
	2018	Green Construction through Wood Program (GCWood)	Program	National
Japan	1987	Legislative Amendment (BSL)	Regulation	National
	1998	Legislative Amendment (BSL)	Regulation	National
	2010	Act for Promotion of Use of Wood in Public Buildings	Act	National
	2014	Roadmap for Disseminating CLT (MLIT) Strategy	Strategy	National
Switzerland	2009	Wood Resource Policy & Wood Action	Act /Program	National
European Union (EU)	2006	EU Sustainable Devel. Strategy	Program/Strategy	international
	2011	EU Roadmap 2050	Strategy	international
	2011	Construction Product Regulation	Act	international
	2013	FTP Vision 2030	Strategy	international
Germany	1990	Wood Sales Incentive Fund Law	Act	National
	2000	Offensive Holz & Natürlich Holz	Campaign	National
	2002	Legislative Amendment (Musterbauordnung)	Regulation	National
	2002	Charta für Holz (Wood Contract)	Program	National
Holland	2013	Dutch Design Initiative – A Dime for a House (10 cents)	Program	National
France	2016	ADIVBOIS	Program	National
	2020	Sustainability Law	Act	National
UK	1991	Legislative Amendment	Regulation	National
	2000	Timber 2000	Campaign	National
	2003	Modern Methods of Construction	Strategy	National
	2008	Greener homes for the future	Campaign	National
	2012	Timber First	Campaign	National
Australia	2015	Wood Promotion Policies (WEP)	Act	Local
New Zealand	2015	Wood First Policy	Act	Local
Turkiye	2018	Project to Popularize the Use of Wood	Program/Strategy	National
	2023	Promoting Low-Cost Energy-Efficient Wooden Buildings	Program/Strategy	National

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According to the data stated and taken into consideration above, it can be said that an average of 12 tons of iron is used for an average 100 m^2 reinforced concrete house.

Similar to the calculation above, one of the main components of construction is the amount of concrete used. In practical terms, the quantity of concrete is the volume occupied by the concrete. In a building of 100 m^2 total building square meters x 0.38 = 38 cubic meters and 40 m^3 of concrete is used, taking into account a calculation error of approximately 10% (Sebeltaş 2022). Since 1 m^3 concrete is 2.5 ton on average, 100 tons of concrete is used per 100 m^2 housing construction (Birimfiyatım 2019).

In a 120 m^2 wooden house/building, the amount of wood material to be used is 30 m^3 (Shams *et al*. 2011; Birimfiyatım 2019; Tirth *et al.* 2019). For 100 m^2, if we need to make a proportion, it should be noted that 25 m^3 of wood material is used.

In sum, regarding the 100.000 items of housing construction with 25 m^3 wood materials per unit, 25m^3 x 100.000 = 2.5 million m^3 annual wood materials are to be used.

The calculation of CO_2 Emission levels in iron and steel production should also be addressed here. In Turkiye, carbon emission calculation in steel production is done in three stages:

1- Scope 1: CO_2 emission of the production process,
2- Scope 2: CO_2 emission values in logistics and process at the source of production inputs
3- Scope 3: CO_2 emissions from the production of the purchased energy type (Birimfiyatım 2019)

In Turkiye, currently, only greenhouse gas emissions from Scope 1 are verified and registered annually by accredited authorized bodies. Scope 1 total emission in EAF is 378 kg CO_2/ton steel, whereas in BDÇ/IF this value is 248 kg CO_2/ton. Therefore, on average, it can be said that 378 + 248 = 626/2= 313 kg CO_2/ton iron and steel. Hence, in the construction of a 100 m^2 reinforced concrete house, 313 kg * 12 tons = 3756 kg of CO_2 emissions are emitted due to the use of iron and steel in a100 m^2 reinforced concrete house building. In total 100.000 houses the quantity is 3756 kg * 100.000 = 375.600.000 kg, which is 375.600 tons $MtCO_2$ emission.

The main ingredient and emitting component of concrete production is cement. In a calculation made for Konya Cement Factory, 220.409.175 tons of CO_2 were emitted for 239600 tons of cement produced annually. In this case, 220.409.175 tons CO_2/239.7600 tons Cement = 0.0919 tons CO_2/1-ton cement. This shows that 91.9290 kg CO_2/ton of cement is emitted in the production of 1 ton of cement (Kara *et al*. 2018). Hence, in the construction of a 100 m^2 reinforced concrete house, 100 m^3 concrete *91.9290 kg CO_2 = 9193 kg of CO_2 emissions are emitted due to the use of cement. In total 100.000 houses the quantity is 9193 kg * 100.000 = 919.300.000 kg, which is 919.300 tons $MtCO_2$ emission. Consequently, in the construction of a 100 m^2 house in reinforced concrete construction, 3756 + 9193 = 12.949 kg CO_2 is emitted due to a-100 m^2 housing construction by using iron and steel and concrete. In sum in the construction of 100.000 houses with a 100 m^2 in reinforced concrete construction, 1.294.900.000 kg CO_2 emitted, which is 1.249.000 $MtCO_2$. In contrast to the above emissions, the 25 m^3 of wood used in the construction of a 100 m^2 house can sequester around 15 m^3 of carbon, depending on the carbon sequestration coefficient. In the Trabzon region, the following allometric equations were developed to calculate the carbon stored in the tree trunk of beech tree species for a maximum stand age of 34 years and calculated as Stem Biomass (Kg, in bark) =0.927-0.611×d+0.289×d^2, R^2 = 0.977, Sy.x = 6.2 kg (Iklimin 2018). In a study conducted in the

Kastamonu region, the average biomass values calculated in the test areas of larch wood components were measured in the trunk wood with the highest 9.25 kg in a single tree (Pirizoğlu 2019). In the study conducted by Mısır *et al*. (2011) concerning (Tolunay 2009) the amount of carbon sequestered in the trunk wood of yellow pine trees was 51.2% (Mısır *et al*. 2011). The rate at which atmospheric CO_2 accumulates in the atmosphere can be reduced by taking advantage of its accumulation as carbon in vegetation and soils in terrestrial ecosystems (UNFCCC 2015). The total CO_2 accumulated or released through forest management can be calculated by considering that 1 ton of stored carbon corresponds to the removal of 3.67 tons of carbon dioxide from the atmosphere (Iklimin 2018). It can be said that 25 m^3 of wood material is approximately 15 tons. It is therefore possible to consider all 25 m^3 of construction material wood as carbon. However, the amount of CO_2 that needs to be sequestered from the atmosphere to store this amount of carbon is calculated as 15 tons of wood *3.67 tons CO_2 sequestered each ton wood = 55.05 tons. Thus, the use of wood materials sequesters approximately 55 tons (55,000 kg) of CO_2 per 100 m^2 of wooden house construction.

Consequently, 55 tons *100.000 houses = 5.500.000 tons of CO_2 sequestered from the atmosphere due to the construction of a 100.000 houses with 100 m^2 by using 25 m^3 wood materials in each one instead of construction by using iron and steel and concrete.

Wood material as an alternative source

The use of wood material as an alternative material in various sectors, especially in the construction sector, contributes positively to the emission balance sheet. For example, a study in Brazil found that the construction of houses entirely using steel and cement is a negative contribution to the national emissions balance sheet of the construction sector. Social housing made of wood is much more affordable and safer than houses made of other materials. The use of wood helps in the fight against global warming. Using sustainably produced wood in construction provides various benefits to society, the economy, and the environment (Zanetti and Casagrande 2009). Replacing concrete and steel with wood is strategically important for emission reduction (Myllyviita *et al*. 2022). Many studies have been conducted on this subject, taking into account different factors (Kapambwe *et al*. 2009; Makineci *et al*. 2017; Matsumoto *et al*. 2022). For example, the study by Howard *et al*. (2021), at the end of 100 years, draws attention to the use of wood building materials in electricity generation. In another study (Santi *et al*. 2016), the emissions from the use of mass wood materials were compared with brick masonry. In a study measuring the amount of wood in residential buildings, it is noted that wood material can be recycled over short periods, providing a potential resource (Nasiri *et al*. 2021). A study by Talvitie *et al*. (2021), which noted that wood structures significantly reduce emissions, focused on determining the practical feasibility from an economic perspective.

In the Russian Federation, roundwood production increased from 143 million cubic metres in 2010. It is expected to reach over 300 million cubic metres in 2030. To meet such an expectation in domestic market, it is reasonable to encourage constructing wooden houses (Petrov and Lobovikov 2012). "Housing construction will reach 1 square metre per capita. Industrial and civil construction will also advance…" (Petrov and Lobovikov 2012). "Annually approximately 300 million m^3 wood materials have been produced. Of this amount, 60% has been used in domestic market and the rest has been exported. As of 2010 the monetary value of those export is 9.5 billion USD…" (Petrov and Lobovikov 2012). Russian forests are huge carbon pools having sequestered 500 to 700 million tonnes of carbon annually. The Country alone has almost 90% carbon sink in global boreal forests, including Canada and Scandinavia. Having such high quantity of carbon kept in forest resources Russia may face an emission problem in their permafrost territories due to temperature increment. To overcome such a problem, it may be an opportunity for the Country to increase wooden housing construction (Petrov and Lobovikov 2012). Therefore, the use of wood as an alternate usage as housing construction is a promising way to reduce emissions and increase the contribution of Russia's carbon sink to mitigate climate change.

Deforestation and land use change, from forests to grasslands, agriculture, or human settlement, releases large amounts of stockpiled carbon. The use of wood from sustainable sources helps prevent these changes in rural activities and supports market incentives to grow forestry carbon. Furthermore, increasing society's consumption of wood products leads to the transfer of larger carbon stocks, which in turn allows new trees to sequester even more carbon. Wood product consumption ensures that the forest industry continues to clean the air. The construction and forestry sectors have significant advantages in contributing to emissions reductions by 2030. The construction sector accounts for 30 to 40% of all global emissions, and the forestry sector could respond quickly with an increase in the price of Certified Emission Reductions (CER). Collectively, they can be an important part of reducing the acceleration of global climate change (Zanetti and Casagrande 2009).

There are many positive consequences of building wooden houses instead of traditional concrete/iron structures as below:

- Trees trap carbon as they grow and store it for a certain period, depending on the end-use. When used in construction, carbon can remain stored in wood for hundreds of years.
- Increased afforestation can bring even greater benefits through CO_2 absorption: Areas planted with trees can take even more CO_2 from the atmosphere.
- Replacing emission-intensive raw materials such as cement and iron with wood can increase the potential of wood products to mitigate the impacts of climate change.
- The use of residual wood for energy and increasing the productivity of forest stands further increase the social, environmental, and social benefits of using wood in construction (Zanetti and Casagrande 2009).

The Chicago Climate Exchange (CCX) establishes basic specifications for carbon accounting for long-lived wood products, including the requirement to prove that these products will be in use or landfills after 100 years and to provide evidence that they come from sustainably managed forests and are certified and carbon rights are protected through a sales contract (Chicago Climate Exchange 2009). As a strategy to combat global climate change, traceability and certification are as important as the need to improve technologies, enhance implementation, and extend the life of such materials (Zanetti and Casagrande 2009).

Monitoring the use of wood as an alternative construction material is extremely important and has been addressed by numerous organizations at the global level. The proposal from Instituto Web Florestal (IWF) establishes an electronic system to support the legal accountability of forest resources and track them throughout the production chain. This involves attaching an electronic chip to each tree that allows it to be tracked within a chain-of-custody system and an overall monitoring center, using software to track the wood from the forest to the final consumers. At any point and at any time along the production chain, wood can be inspected and technical, legal, and life cycle data and information provided (Zanetti and Casagrande 2009).

Wood as an alternative construction material requires a life cycle assessment (LCA), which is the investigation and assessment of the environmental impacts of a particular product or service. The carbon content in logs that are converted into finished products and residues depends on several factors such as species, site conditions, harvesting technique, log classification, and conversion efficiency in wood processing plants (Ximenes 2006). Understanding the flow of carbon from harvested logs to different residues (bark, sawdust, cuts, and shavings) and product streams is important. Different products have different service lives, and domestic framing typically has a long service life (Zanetti and Casagrande 2009).

Disposal (destruction) is a critical stage in the life cycle of forest products in terms of its ultimate impact on emissions. Estimating parameters to account for carbon along the production chain can include factors such as national industry averages of the volume of forest products produced and the fate of products after disposal. These are critical factors in determining the level of long-term storage of forest products (Zanetti and Casagrande 2009). Turkiye's Eleventh Development Plan (2019 to 2023) prioritizes increasing the use of wood and encourages the use of wood by stating that "415.5. Utilizing wood will be made widespread and standards will be set". OGM (General Directorate of Forestry) aims to increase the use of wood in Turkiye's construction sector through the use of advanced wood technologies with the "Promoting Low-Cost Energy Efficient Wooden Buildings in Turkiye Project (2023-2029)".

Consequently, constructing high-quality houses from wood can both reduce the contribution of the construction sector to global warming and increase the CO_2 sequestration of forests. Increasing the number of tree species used in house construction can also contribute to the variety of trees that can be used (Zanetti and Casagrande 2009).

Work needs to be done to transform public and professional understanding of the role of wood and forests in global climate change and to promote the cultural rehabilitation of wooden houses in the community (Zanetti and Casagrande 2009). There is a need for an accounting system that traces forestry carbon from stands to products and allows participants to estimate the contribution of wood products to reducing emissions from land-use change and increasing carbon sequestration in forested areas. Such a system could be used to promote the role of wood and its use in combating global climate change (Zanetti and Casagrande 2009).

Amount of emissions generated and emissions trading potential

As mentioned above, in the construction of a 100 m^2 reinforced concrete house, 3756 + 9193 = 12.949 kg CO_2 is emitted. In contrast, if a house of the same size is built with wood, approximately 55 tons (55,000 kg) of CO_2 is sequestered. In this case, the scenario calls for the construction of 100,000 single-storey wooden houses in Turkiye, especially in rural areas.

Therefore, total amount of carbon credits tradable equals the addition of both total sequestered carbon (5,500,000 $MtCO_2$) and total CO_2 emissions reduced (1.294.900 $MtCO_2$), which is 6.794.900 ton $MtCO_2$.

In Russia, it is estimated that 300 million m^3 round wood production will occur. Since 60% of it has been consumed in the domestic market, the remaining 40%, which is 120 million m^3, has been exported. The country promises to use a huge amount of wood in housing construction. When considering 2,500,000 m^3 wood used in 100,000 housing as in the case in Turkiye and sequester 55.000 $MtCO_2$, it is a reality that by using 120 million m^3 wood in Russia in housing construction (100.000*48=4.800.000 houses) as a scenario, 55.000 million MtCO$_2$* 48 (120.000.000/2.500.000) equals to 2.640.000.000 MtCO$_2$ might be sequestered. Therefore, it is estimated that in Russia the carbon sequestration potential for housing construction is 48 times more than that of Turkiye.

Table 3. Amount of CO$_2$ Emissions Captured

Number of houses	Amount of CO$_2$ emissions reduced - kg CO$_2$/per household	Total -kg of CO$_2$ emissions reduced	Amount of CO$_2$ sequestered - kg CO$_2$/per household	Total -kg of CO$_2$ sequestered	Grand Total - kg of CO$_2$ emissions reduced
100,000 – single-storey	12.949	1.294.900,000	55,000	5,500,000,000	6,794,900,000
TOTAL		1.294.900,000		5,500,000,000	6,794,900,000
					6,794,900 Ton
100,000 – single-storey	12.949	1.294.900,000	55,000	5,500,000,000	6,794,900,000
TOTAL		**1.294.900,MtCO$_2$**		**5,500,000MTCO$_2$**	**6,794,900 MtCO$_2$**

DISCUSSION

This study presents the potential for emission trading of forest carbon sequestered in Turkiye's forests, its limitations, and the carbon credit and its commercial potential if the wood is used as a building material for reinforced concrete housing constructions, which is one of the alternative carbon credit scenarios.

Russia was used as an example, and the wood of the two nations and their approaches to the carbon trade system were compared, to better understand the position of forests with carbon sequestration systems in the potential of the carbon trade. When comparing the forest carbon sequestration systems of Turkiye and Russia, it becomes clear that Russia can overtake Turkiye at the global summit if it adopts the proper emission reduction strategies and takes advantage of its abundance of forested resources. It even has a strong potential for mitigation at a reasonable price, it can be said. It is recognized that significant progress can be made in lowering greenhouse gas emissions given the expectation that log production will reach the 2030 objective (over 300 million m^3) and with the adoption of incentive policies for wood use. Forest carbon sinks are already given priority in government mitigation plans. It is anticipated that significant progress will be made in preventing emission reductions (2,640,000,000,000 billion tons of sequestered CO$_2$) with the target of using wood instead of steel or concrete in houses by 2050.

More practical strategies are required to increase the potential frontier for emissions trading as compared to Turkiye's approach to forest carbon sequestration. Due to limitations in providing intrinsic value and the leakage issue, the emission trading potential of forest carbon trapped in Turkiye's forests remains incredibly low. For this reason, government regulations should provide alternate uses of wood material a lot of room. On the other hand, the voluntary carbon market has made a major contribution to the efforts made to cut carbon emissions. With the implementation of voluntary markets and support for the growth of regional carbon pricing systems, the Paris Agreement has had a favorable impact on the structure of the carbon market. This process is supported by the prediction that between 2021 and 2035, demand for carbon credits will range between 1.6 and 3.7 billion tons. Although many initiatives involve forests, it is crucial that the criteria that projects must meet to be approved as carbon credits in the market are included in carbon stock calculations and reporting. The fact that carbon rights are protected by law is another crucial factor. When the situation in Turkiye is examined, it becomes clear that modifications need to be made to the law regarding issues including intrinsic value, leakage, measurability, and variations in the definition of a forest. First and foremost, this requires that realistic methodologies be used to broaden the possible limit of emission trading and commit to targets that will allow for the certification of a tiny percentage of the overall amount of carbon sequestered. The research supports the premise that developing alternate applications for wood products can greatly increase the quantity of forest carbon that can be subject to emission trading. Additionally, since the construction industry alone is responsible for between 30 and 40 percent of all global emissions, it makes sense that the forestry and construction sectors would be leading the charge in slowing the pace of the global climate crisis. In the fight against climate change, strategies and market incentives that support these industries based on sustainability are required. Conducting life cycle studies and promoting alternative uses of wood in the construction industry are crucial steps in the process. It is acknowledged that major advancements in lowering carbon emission sequestration can be realized with diligent monitoring and analyses. On the other hand, the provision of carbon credits through afforestation is subject to technical and regulatory limitations. Laws need to be revised, since they are susceptible to violations of ownership and entitlement. The legislation may specifically cover land ownership, planning, entitlement, and utilization, as well as social impact analysis and oversight.

The results obtained are very promising and the CO_2 emissions sequestered or reduced from the atmosphere is 6,794,900 $MtCO_2$ if wood materials are used in housing constructions instead of concrete, iron, and steel materials. Besides, carbon prices have reached 80 euros in Europe, the market price of a certified metric ton of carbon emissions (Zakeri and Staffell 2023). The total emission trading potential in the scenario for the construction of 100,000 wooden houses corresponds to 6,794,900 $MtCO_2$ * EUR 80 = EUR 543,592,000. In addition, since the wood shall be used in housing construction is 120 million m^3 and the number of houses built with such an amount of wood are 4,800,000, the result obtained is much more promising in Russia and the CO_2 emissions sequestered or reduced from the atmosphere is 2,640,000,000 $MtCO_2$ if wood materials are used in housing constructions instead of concrete and iron and steel materials. Besides, carbon prices have reached 80 euros in Europe, the market price of a certified metric ton of carbon emissions (Zakeri and Staffell 2023). The total emission trading potential in the scenario for the construction of 4.800,000 wooden houses corresponds to 2,640,000,000 $MtCO_2$ * EUR 80 = EUR 211,200,000,000. Therefore, it is even a promising potential for Russia to make an equal amount of money to exporting oil and gas, which is about 240 billion USD in 2021 (Reuters 2022). Because the wood material used for a 100 m^2 house is 25 m^3, the total amount of timber for 100,000 houses is 25*100,000 = 2.500.000 m^3 according to this scenario. Approximately 9 kg of carbon in the trunk wood of a tree, for 6,794,900 $MtCO_2$ of carbon (6,794,900 tons * 1000) /9 kg/tree = 754.988.988 trees. Assuming 500 trees per hectare, an area of 1,509,977 hectares needs to be cut and reforested. The amount of carbon that this new afforested area will sequester during the management period, which can be

30 years, should also be added to the positive side of this balance sheet. Similar scenario is applicable for Russia that it is 48 times more potential of afforestation and thus 1.509.977 ha.* 48 = 72.478.933 ha. of new afforestation areas.

CONCLUSIONS

1. New experiences and innovative strategies must be incorporated into national policies in order to realize the potential of the promises made by nations under international agreements on emission reduction. One of these strategies is to reduce emissions by using wood products derived from forestry resources in alternative ways. As can be observed from the examples of Russia and Turkiye, different countries' approaches to forest carbon systems and the realization of the potential for trade depend on a variety of issues such as limitations in supplying intrinsic value and the leakage problem, low duration of management, and poor productivity. In this situation, it would be prudent to include incentive policies for alternate uses of wood production, such as the construction of wooden dwellings, in the context of sustainability. Additionally, it will be advantageous for carbon trading systems if a good contribution can be made to the trade potential in terms of mitigation and adaptation.
2. It is concluded that policies for emission reduction are still evolving favorably, with outcomes including the Paris Agreement's ongoing carbon market structure and encouragement of regional carbon pricing systems. One of the important concerns raised here is the requirement for a legal framework that protects carbon rights. To assure sustainability, it will be crucial to view this system as a whole "climate change legislation package."
3. Although it is obvious that the amount of forest carbon sequestered in Turkiye's forests is 3 billion m^3, the potential for emissions trading of such a large amount of carbon remains extremely low due to the leakage problem and limitations in providing intrinsic value. If instead, the carbon sequestered in these sources were to be used as wood material in housing construction, an additional 1,509,977 hectares of land would be cut, requiring an additional annual wood production that provides intrinsic value.
4. The forest carbon sequestered in Turkiye's forests represents approximately 6,794,900 tons of CO_2 emission credits and a carbon trading potential of about 550 million Euros.
5. The availability of emission credits in Turkish forest areas is limited due to the intrinsic value criterion. Therefore, more carbon credits can be obtained by turning to alternative uses of wood material. Approximately 6,794,900 metric tons of additional carbon sequestration is possible by using wood in housing construction as an alternative to iron and steel and concrete. This would generate a profit of around EUR 550 million in emission credits.
6. The implementation of wood incentive programs around the globe is a significant step in the fight against climate change and for environmental improvement. These incentives can be seen as a comprehensive alternative in terms of both domestic economic growth and international emission reduction, pollution reduction, and protection of the right to live in a healthy and balanced environment.

7. The monetary values of carbon credit before the scenario and after the scenario is compared to support whether the increment in monetary values of carbon credit obtained is significant. Thus, the outcome of this study supports the climate change mitigation objective.
8. The total emission trading potential in the scenario for the construction of wooden houses corresponds to EUR 211,200,000,000. Therefore, there is a promising potential for Russia to make an equal amount of money to exporting oil and gas, which is about 240 billion.

REFERENCES CITED

Aliusta, H., Yilmaz, B., and Kırlıoğlu, H. (2016). "Market-based economıc tools applıed ın the process of preventıng global warmıng: Carbon tradıng and carbon tax," *Int. Journal of Management Economics and Business*, ICAFR 16 Special Issue (12), 382-401.

Binboğa, G. (2017). "The Kyoto protocol flexıbılıty mechanısms in the scope of sustaınabılıty and the ınvestıgatıon of sıtuatıon of Turkey," *Celal Bayar University Journal of Social Sciences* 15(4), 207-238.

Birimfiyatım. (2019). "How much m3 of timber is used for a wooden house," (https://birimfiyatim.com/ahsap-eve-kac-m3-kereste-gider/), Accessed: 6 June 2023.

Canadell, J. G., and Raupach, M. R. (2008). "Managing forests for climate change mitigation," *Science* 320(5882), 1456-1457. DOI: 10.1126/science.1155458.

Chicago Climate Exchange (2009). Chicago climate exchange. I ll, CCX Offset Project Protocol: Forestry Carbon Sequestration Report, https://www.ice.com/publicdocs/ccx/protocols/CCX_Protocol_Forestry_Sequestration.pdf (Accessed: 23.05.2023)

Çınar, M. C. (2018). *Turkish Construction Sector and the Effects of the Turkish Construction Sector on the National Economy* [Master's Thesis, T.C. Nevşehir Hacı Bektaş Veli University Institute of Social Sciences, Department of Economics].

Dağlı, H. (2019). "Economıc fınancıal vehıcles for fıghtıng clımate change: Carbon tax," *Journal of International Banking, Economy and Management Studies* 2(2), 30-42. Retrieved from https://dergipark.org.tr/tr/pub/ubeyad/issue/48439/569997

Duel, A. (2021). Сибирские леса накопили 13,8 млрд тонн углерода (Siberian forests have accumulated 13.8 billion tons of carbon), (https://rg.ru/2021/01/18/sibirskie-lesa-nakopili-138-mlrd-tonn-ugleroda.html), Accessed 9 November 2023.

Ecer, M. (2010). İklim Değişikliği ve Emisyon Ticareti Mekanizmaları. TC Çevre ve Orman Bakanlığı Çevre Yönetimi Genel Müdürlüğü İklim Değişikliği Dairesi Başkanlığı (Climate Change and Emission Trade Mechanism. T.C. Ministry of Environment and Forestry, General Directorate of Environmental Management, Department of Climate Change), Ankara.

Elitas, C., and Çetin, A. C. (2011). "Carbon trading and carbon banking," *Accounting & Auditing Perspective Magazine* 11(35).

Eskander, S., Fankhauser, S., and Setzer, J. (2021). "Global lessons from climate change legislation and litigation," *Environmental and Energy Policy and the Economy* 2, 44-48. DOI: 10.1086/711306

FAO (2012). The Russian Federation Forest Sector Outlook Study to 2030.
FAO (2020). Global Forest Resources Assessment 2020: Main report. Rome. DOI: 10.4060/ca9825en, Accessed 9 October 2023.
Forestcomplex. (2023). A national system for monitoring carbon in ecosystems will appear in Russia," (https://forestcomplex.ru/forestry/v-rossii-poyavitsya-nacionalnaya-sistema-monitoringa-ugleroda-v-ekosistemah/), Accessed 9 November 2023.
GDF (2020). Annual activity report of General Directorate of Forestry, Ankara (https://www.ogm.gov.tr/tr/e-kutuphane-sitesi/FaaliyetRaporu/Orman%20Genel%20M%C3%BCd%C3%BCrl%C3%BC%C4%9F%C3%BC%202019%20Y%C4%B1l%C4%B1%20Faaliyet%20Raporu.pdf), Accessed 20 March 2023.
GDF (2021). "Annual activity report of General Directorate of Forestry," (https://www.ogm.gov.tr/tr/e-kutuphane-sitesi/FaaliyetRaporu/Orman%20Genel%20M%C3%BCd%C3%BCrl%C3%BC%C4%9F%C3%BC%202020%20Y%C4%B1l%C4%B1%20Faaliyet%20Raporu.pdf), Accessed 20 March 2023.
Hamrick, K., and Gallant, M. (2017). "Unlocking potential: State of the voluntary carbon markets 2017," *Forest Trends' Ecosystem Marketplace.*
Hernandez, H. K., (2020). *Development of Conceptual Architecture of Carbon Certification System within the Scope of Sustainable Forest Management Project*, S. Association. https://www.tohumdernegi.org/wp-content/uploads/2020/03/Yusuf_2020_03_11_k.pdf
Iklimin. (2018). "Common management guidelines for ıncreasing carbon sequestration in forests," Development of a Common Protocol to Assess the Impact of Forest Management Practices on Climate Change, Issue. https://www.iklimin.org/wp-content/uploads/2018/01/1.-K%C4%B0TAP_D4.5_T%C3%9CRK%C3%87E.pdf
Jandl, R., Lindner, M., Vesterdal, L., Bauwens, B., Baritz, R., Hagedorn, F., Johnson, D.W., Minkkinen, K., and Byrne, K. A. (2007). "How strongly can forest management influence soil carbon sequestration?," *Geoderma* 137(3-4), 253-268. DOI: 10.1016/j.geoderma.2006.09.003
Kapambwe, M., Ximenes, F., Vinden, P., and Keenan, R. (2009). *Dynamics of Carbon Stocks in Timber in Australian Residential Housing*, Forest and Wood Products Australia, Melbourne, Australia.
Kara, G., İbiç, İ. A., and Yağcıoğlu, E. (2018). "Greenhouse gas emissions from cement ındustry," *National Environmental Science Research Journal* 1(2), 87-90.
Karal, K., and Gencay, G. (2020). "Investigation of legal dimensions of the ımpacts of deforestation on global climate change," *Journal of Bartın Faculty of Forestry* 22(2), 571-579.
Karluk, R. (2005). *Türkiye's Economy from the Declaration of the Republic to the Present* , lO.P. İstanbul, Beta.
Korkmazhaber. (2021). "100 mt^2 eve kac ton demir gider," (https://korkmazhaber.com/100-mt2-eve-kac-ton-demir-gider-mt2-demir-hesaplama-25258.htm), Accessed 28 January 2023
Leskinen, P., Lindner, M., Verkerk, P. J., Nabuurs, G. J., Van Brusselen, J., Kulikova, E., Hassegawa, M., and Lerink, B. (eds.). (2020). "Russian forests and climate change. What science can tell us," 11. European Forest Institute. DOI: 10.36333/wsctu11
Lynn, J. (2023). "Russia develops their own carbon credit methodologies,"

(https://carboncredits.com/18-russian-carbon-credits-methodologies-are-underway/), Accessed 9 October 2023.
Makineci, E., Akburak, S., Özturna, A. G., and Tolunay, D. (2017). "Carbon stocks of fine woody debris in coppice oak forests at different development stages," *Forests* 8(6), 199. DOI: 10.3390/f8060199
Matsumoto, R., Kayo, C., Kita, S., Nakamura, K., Lauk, C., and Funada, R. (2022). "Estimation of carbon stocks in wood products for private building companies," *Scientific Reports* 12(1), article 18112.
Mediawood. (2023). "Forestry industry development strategy until 2030," (https://mediawood.ru/strategiy_razvitiy_lesnoi_otrasli_do_2030_new), Accessed 13 September 13 2023.
MEU. (2018). "Report on Turkey's 7th National Communication," (https://webdosya.csb.gov.tr/db/cygm/icerikler/yed-nc--ulusal-b-ld-r-m-20190909092640.pdf), Accessed 19 January 2023.
Mısır, N., Mısır, M., and Ülker, C. (2011). "Determining carbon stock," in: *I. National Mediterranean Forest and Environment Symposium,* 26-28 October, Kahramanmaraş, KSU J. Nat. Sci., Special Issue 2012
MoEF. (2008). "Flexibility mechanisms of the Kyoto protocol and other ınternational emissions trading systems," Specialization Commission Report on the Ministry of Environment and Forestry. d. Ankara, with No. B.18.ÇYG.0.02.00.04-020/8366, p.43.
Myllyviita, T., Hurmekoski, E., and Kunttu, J. (2022). "Substitution impacts of Nordic wood-based multi-story building types: Influence of the decarbonization of the energy sector and increased recycling of construction materials," *Carbon Balance and Management* 17(1), 4. DOI: 10.1186/s13021-022-00205-x
Nasiri, B., Piccardo, C., and Hughes, M. (2021). "Estimating the material stock in wooden residential houses in Finland," *Waste Management* 135, 318-326. DOI: 10.1016/j.wasman.2021.09.007
Nordregio (2023). "Wood in construction industry in Russia present state challenges and prospects," (https://nordregioprojects.org/blog/2021/02/02/wood-in-construction-industry-in-russia-present-state-challenges-and-prospects/#/home), Accessed 13 September 2023.
Oral, H. V. (2020). "The ımportance of ıntegrating the urban forest carbon potential to the Turkey voluntary carbon credit market," *Journal of Bartin Faculty of Forestry* 22(1), 199-207.
Peker, H. S., and Altinişik, İ. (2011). "Carbon trade ın terms of ınternalısatıon of negatıve externalıtıes," *Gümüshane University Electronic Journal of the Institute of Social Science,* 2(4).
Petrov, A., and Lobovikov, M. (2012). "The Russian federation forest sector: Outlook study to 2030," *FAO, Rome*.
Pirizoğlu, A. (2019). *Determination of the Amount of Carbon Above Ground in Black Pine (P. nigra) Stands of Young Development Stage,* Masters Thesis, Kastamonu University, Kastamonu.
Reuters (2022). Russia's oil and gas revenue windfall. https://www.reuters.com/markets/europe/russias-oil-gas-revenue-windfall-2022-01-21. Access: 21.09.2023.
Russian Federation. (2021). *Strategy for the Socio-Economic Development of Russia with Low Greenhouse Gas Emissions until*

2050. http://static.government.ru/media/files/ADKkCzp3fWO32e2yA0BhtIpyzWfHaiUa.pdf.

Russian Federation. (2022). "Strategy for the socio-economic development of Russia with low greenhouse gas emissions until 2050," UNFCCC Long-Term Strategies Portal. https://unfccc.int/sites/default/files/resource/Strategy%20of%20Socio-Economic%20Development%20of%20the%20Russian%20Federation%20with%20Low%20GHG%20Emissions%20EN.pdf.

Safonov, G., Kozeltsev, M., Potashnikov, V., Dorina, A., and Semakina, A. (2022). "Potential role of bioenergy in decarbonizing Russia's economy," [Потенциал Биоэнергетики В Декарбонизации Экономики России]. *Economic Policy*, *6*, 90-111.

Santi, S., Pierobon, F., Corradini, G., Cavalli, R., and Zanetti, M. (2016). "Massive wood material for sustainable building design: The Massiv–Holz–Mauer wall system," *Journal of Wood Science* 62, 416-428.

Sathre, R., and Gustavsson, L. (2009). "Using wood products to mitigate climate change: External costs and structural change," *Applied Energy* 86(2), 251-257. DOI: 10.1016/j.apenergy.2008.04.007

Sebeltaş. (2022). "Practical calculation of the amount of concrete", (https://sebeltas.com/beton-miktari-hesabi) Accessed 29 June 2023.

Serengil, Y. (2020). Development of conceptual architecture of carbon certification system within the scope of sustainable forest management project. S Association. (Accessed August 19, 2023). https://www.tohumdernegi.org/wp-content/uploads/2020/03/Yusuf_2020_03_11_k.pdf

Shams, S., Mahmud, K., and Al-Amin, M. (2011). "A comparative analysis of building materials for sustainable construction with emphasis on CO_2 reduction," *International Journal of Environment and Sustainable Development* 10(4), 364-374. DOI: 10.1504/IJESD.2011.047767

Shigui, D. (2023). *No Brainers and Low-Hanging Fruit in National Climate Policy*, F. Caselli, A. Ludwig, and R. van der Ploeg (eds.), CEPR Press, London, 2021: 244 pages; eBook ISBN: 978-1-912179-51-0.

Şişman, M. E., and Ökten, B. B. (2023). "Wood incentive policies and effects in the construction sector," *Bab Journal of FSMVU Faculty of Architecture and Design*, (Special Issue), 48-64.

Sivrikaya, F., and Bozali, N. (2012). "Determining carbon stock: A case study from Türkoğlu plannıng unıt," *Journal of Bartın Faculty of Forestry* 14(1. Special Issue), 69-76.

Smith, P., Bustamante, M., Ahammad, H., Clark, H., Dong, H., Elsiddig, E. A., Haberl, H., Harper, R., House, J., Jafari, M., (2014). "Agriculture, forestry and other land use (AFOLU)," in: *Climate Change 2014: Mitigation of Climate Change*. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (pp. 811-922), Cambridge University Press. (https://orbit.dtu.dk/en/publications/agriculture-forestry-and-other-land-use-afolu) Accessed: 23.08.2023.

Talvitie, I., Vimpari, J., and Junnila, S. (2021). "Economic feasibility of wood-based structures—improving urban carbon neutrality strategies," *Environmental Research: Infrastructure and Sustainability* 1(1), 011002. DOI: 10.1088/2634-4505/abfe05

TASS. (2022). *The Ministry of Economic Development will update the implementation plan for the low-carbon development strategy of Russia*.

https://tass.ru/ekonomika/16121487.
Tirth, V., Algarni, S., Agarwal, N., and Saxena, A. (2019). "Greenhouse gas emissions due to the construction of residential buildings in Moradabad, India," *Applied Ecology and Environmental Research* 17(5), 12111-12126. DOI: 10.15666/aeer/1705_1211112126
Tolunay, D., and Çömez, A. (2007). Solution of Global Climate Change and Water Problems Symposium, 13- 14 December, 2007, Istanbul, pp. 97-107.
Tolunay, D. (2009). "Carbon concentrations of tree components, forest floor and understorey in young *Pinus sylvestris* stands in north-western Turkey," *Scandinavian Journal of Forest Research* 24(5), 394-402. DOI: 10.1080/02827580903164471
Turker, Y. O., and Aydın, A. (2022). "How ready is the Turkish Legislation for the green deal," *Energy and Climate Change* 3, 100084. DOI: 10.1016/j.egycc.2022.100084
Ubay, B., and Bilgici, Y. (2021). "Emıssıon tradıng system and ıts ımportance in carbon pricing," *Kırklareli University Journal of the Faculty of Economics and Administrative Sciences* 10(1), 47-72. Retrieved from https://dergipark.org.tr/en/pub/klujfeas/issue/61104/853559
Ülgen, H., and Güneş Y. (2016). "Afforestation carbon," Nature Conservation Center, Ankara.
UNFCCC. (2015, January 20, 2023). *UN Climate Change Annual Report Paris*: United Nations Convention on Climate Change (UNFCCC). https://unfccc.int/sites/default/files/resource/UN-Climate-Change-Annual-Report-2018.pdf
Uyar, S., and Cengiz, E. (2011). "Carbon (greenhouse gas) accounting," *Journal of Financial Analysis* (105), pp. 47-69. (https://gavsispanel.gelisim.edu.tr/Document/ezozer/20190924145111767_33960484-7ae2-4f3d-944d-8402515ae8e5.pdf), Accessed 5 December 2023.
Vakur, S. (2014). *Environmental Problems and Climate Change. Şaban Kardaş, Ali Balcı (der)*,'Uluslararası İlişkilere Giriş', İstanbul: Küre, 5.
Woodru. (2023). https://www.wood.ru/ru/lonewsid-7571.html. Accessed 9 October 2023.
World Bank (2020). "Pricing carbon," (https://www.worldbank.org/en/programs/ pricing-carbo), Accessed 21 July 2 2022.
Ximenes, F. (2006). *Carbon Storage in Wood Products in Australia: A review of the Current State of Knowledge*, Report, Forest and Wood Products Research and Development Corporation, Victoria (Australia), 26 p.
Yetiş, Ş., and Özden, S. (2020). "Development of carbon marketing in Turkey and its effect to forestry," *The Journal of Social Sciences* 34(34), 457-477.
Yılmaz, B. (2019). "The future of energy sector: Carbon trading," *Science Journal of Turkish Military Academy* 29(1), 65-91.
Zakeri, B., Staffell, I., Dodds, P. E., Grubb, M., Ekins, P., Jääskeläinen, J., Cross, S., Helin, K., and Castagneto, G. G. (2022). *Energy Transitions in Europe – Role of Natural Gas in Electricity Prices* (July 23, 2022). Available at SSRN: (https://ssrn.com/abstract=4170906), DOI: 10.2139/ssrn.4170906) Accessed 23 July 2022.

Zanetti, E., and Casagrande. (2009). "Wood from sustainable sources and the mitigation of global climate change - Case study of social interest housing in Curitiba, Parana, South of Brazil" in: *Forests and Climate Change: Adaptation and Mitigation, E. 3.4 social housing in curitiba, paraná state, Brazil,* Issue: 50, November 2009, pp. 76-83.

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