THE ROLE OF GEOMATICS ENGINEERING IN CLIMATE CHANGE STUDIES

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ABSTRACT:

Geomatics Engineers acquire, manage, analyse, model and present the geo-spatially referenced data quickly, accurately and reliably. They can classify the derived data with geographic information systems and produce many models according to needs. This study focuses on the role of the geomatics discipline in combatting climate change, the capability of measuring climate change parameters and the determination of the causes of the parameters change. Basic information about the latest developments in the Geomatics discipline for climate change studies is given. Geomatics Engineer's studies for understanding Earth’s system and its response to climate change and models created for the solution are explained. Geomatics Engineering provides a wide range of geospatial data and produces applications for understanding climate change. They take place in climate change analyses by measuring various climate parameters, and by processing the atmosphere, land, glaciers and waters in various spatiotemporal analyses. The obtained results have shown the significantly important role of the geomatics discipline in obtaining, monitoring and analysing the data used for climate change effects’ mitigation. In conclusion, Geomatics Engineering contributes to the decision-makers who have a duty in struggling with climate change and all stakeholders of the subject together with practitioners at all levels to create a road map for the studies to be carried out.

1. INTRODUCTION

The global scientific community agreed with the acceptance that the climate system of the Earth is collapsing due to human effects (IPCC, 2013). Climate factors, such as heavy rains above the mean values, increases in the temperature averages, droughts, floods, rapid melting of the land and sea glaciers, and rising sea levels have been seen to be changing in the world since the beginning of the last century. These natural phenomena are considered to be indicators of the existence of global climate change. The increasing use of natural resources due to today’s consumption habits and the rising population quickens the climate change process and causes the adverse effects to increase. Climate change has become an important natural or anthropogenic problem that should show different effects on different regions and can harm the world irrevocably. Surface temperature, ocean heat content, atmospheric carbon dioxide (CO_2) (Green House Gasses, GHGs), ocean acidification, sea level, glacier and Arctic & Antarctic sea ice extent are the 7 parameters declared by the World Meteorological Organization (WMO) for the determination of climate change (WMO, 2021). The worldwide energy use, transportation, urbanization and agriculture and forestry policies and applications can be stated as the causing effects of the changes in the climate change parameters.

World Commission on Environment and Development published the Brundtland report in 1987, which is a document entitled Our Common Future. The sustainable development concept is declared and defined as “*meet the necessities of the present generation without harming the future generation's capacity to meet their own*”. United Nations (UN) has a key role in policy-making for sustainable development. At the end of all the efforts and studies, the UN launched 17 Sustainable Development Goals (SDGs) with 169 targets in 2015 and aimed to be achieved by 2030 to ensure sustainability all over the world (Salvia et al., 2019). The SGD-13 (Goal 13: Climate Action) one of the 17 SGDs is directly deals with climate change and described as; Take Urgent Action to Combat Climate Change and its Impacts. It has 5 targets and 8 indicators (UN, 2023).

There are many international agreements for struggling the climate change, in which Türkiye is also involved. The agreements accepted by the 1992 United Nations Framework Convention on Climate Change (UNFCCC), which took effect on March 21, 1994, aim to reduce the most important reason for climate change greenhouse gas emissions and protect greenhouse gas sinks (forests, lakes/seas/oceans, etc.). The Paris Agreement, which was accepted by almost all countries of the world and put into practice after 2020 by the UNFCCC, set a target of limiting the global temperature increase caused by human-induced greenhouse gas emissions to 1.5°C by the end of the century. Exceeding this threshold is expected to cause to many adverse impacts on the world climate. To achieve this goal, it is necessary to identify the sources that cause greenhouse gas emissions, measure the amount of greenhouse gases they produce, and take necessary precautions to reduce this value. With this, it is necessary to measure all greenhouse gas emissions caused by energy use, land use, transportation, industrial processes, and the use of products, and wastes, and to work towards establishing sustainable management systems to reduce them.

It is estimated that approximately 84% of the total global energy use (electricity, transportation, heating, etc.) is obtained from fossil fuels, and unless necessary international precautions are taken this ratio is expected to remain the same. In 2019, %37 of the global electricity was low carbon. The rest of the electricity

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was obtained from fossil fuels, mostly oil, coal and gas (Figure 1). If humans continue using fossil fuels, carbon dioxide which is the primary reason for greenhouse gas emissions will continue releasing and negatively affecting climate change.

On the other hand, according to The Stated Policies Scenario (STEPS), this number can just fall below 75% by 2030 and remain around 60% by 2050 with certain precautions. It is stated that this amount of global energy consumption will result in significant amounts of CO_2 emissions, which will cause an increase in average global temperatures of about 2.5°C by the end of the century (IEA, 2022).

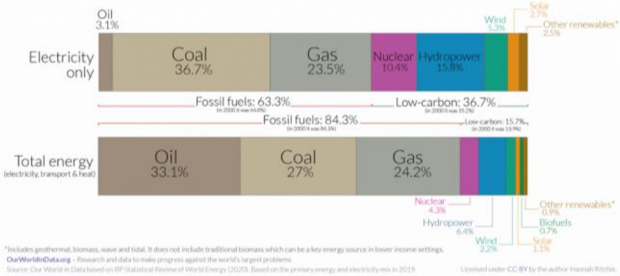

Figure 1. Fossil fuels and low-carbon ratios in electricity-only (*top*) and total energy consumption (*bottom*) (Ritchie, 2021).

According to an ongoing temperature analysis led by scientists at NASA's Goddard Institute for Space Studies (GISS), the average global temperature has increased at least 1.1°C since 1880 (since preindustrial times) and most of this increase occurred since 1975 (NASA, 2023). Intergovernmental Panel on Climate Change (IPCC) states that global warming must be limited to 1.5°C. Considering how much the 1.1°C increase has affected our world, it is clear what kind of problems we will face if the temperature increases more than 1.5°C. If the necessary precautions are not taken regarding climate change, critical problems will occur and these problems will not only concern humanity but also almost every living species on Earth. To overcome the problems related to climate change, which is considered a deeply important threat to the Earth, all related disciplines should work together to decrease the adverse effects. Türkiye as being a partner in the Paris Agreement, aimed the target of net zero emissions by 2053. With this agreement, Türkiye's new climate regime was put into practice and studies have been initiated to mitigate the emerging and potential future impacts of climate change.

The geospatial techniques such as conventional terrestrial, satellite-based GNSS, remote sensing technologies, geographic information systems (GIS), spatial statistics and geo-visualization which are the subject of Geomatics Engineering are the strong arms of decision makers and action plan developers for local government/central government in combatting climate change. This paper discusses the roles that geomatics, as the primary producer and manager of spatial data and its information system structure, plays in reducing the above-mentioned climatic consequences and achieving global goals through the use of geospatial data in the studies that will be conducted.

2. BACKGROUND

According to the International Federation of Surveyors (FIG) Report, which is about the Surveyor's Role in Monitoring, Mitigating, and Adapting to Climate Change "*The surveyor is a practical, pragmatic, people-centric professional person, skilled in spatial measurement, able to represent, interpret and analyse spatial information, highly knowledgeable in the administration and governance of rights to the land and sea, and capable of planning for the development and use of land resources*" (Boateng et al., 2014). The report's goal was to determine and demonstrate how the surveying profession, with its sciences, technologies, professional expertise, and practices, could help the international community in measuring and monitoring climate change. Urban community and settlement designs, peri-urban area and coastal zone management, water and forest resource use, carbon credit market creations, large-scale agriculture growth, physical infrastructure constructions, energy use and conservation, and the disease spread are some applications that affect climate change parameters. Surveyors can combat climate change by; land administration systems, spatial monitoring and measuring, spatial information management, adaptation and disaster risk management, and land-use planning. Surveyors supply significant geographic data for early warning and climate-related mapping and systems that regulate land use and urban growth. The surveyor's work promotes social justice, economic growth, environmental sustainability, and climate change adaptation and mitigation. Surveyors as land professionals are dedicated to collaborating with local communities, trade associations, governmental organizations, and international organizations. Surveyors are already incorporating social, economic, environmental, and geographic data into newly planned and constructed land administration systems to enable the spatial analyses required when asking "what if" questions about climate adaptation. Which geographical areas, for instance, within a given region could be most appropriate for the relocation of climate refugees? What rights do people have there, and who is entitled to what? Is there enough land to support the required infrastructure? Responding to inquiries of this kind leads to the surveyor's additional duties, which include land use planning and disaster risk management. The report is a detailed document about the surveyor's role in combatting climate change (Boateng et al., 2014).

One of the early studies about the role of Geomatics Engineering in climate change was held by the Centre for Earth Observation Science, Department of Geography, University of Manitoba, as a workshop on March 12, 2001. The role of geomatics in climate variability and change was discussed and a final report was published. The report intentionally framed the working document into hydrological, lithological and atmospheric processes. Different sectors, such as snow, sea ice, agriculture, geology, precipitation, droughts, and clouds, are reviewed within each of these spheres. This review's framework looks at the advantages of incorporating data from remote sensing into numerical process models and geographic information systems. The conclusion of the final report of the workshop showed that remote sensing and numerical modelling together can create positive feedback chains that improve both the spatial and temporal representation of the numerical simulations and our overall understanding of the physical system under consideration. The need for complex parameterizations in numerical models can be decreased by using remote measurements (Mosscrop et al., 2001).

3. NATIONAL AND INTERNATIONAL POLICIES IN CLIMATE CHANGE

Intergovernmental Panel on Climate Change (IPCC) evaluation reports state that climate change should highly affect the Mediterranean Basin. Türkiye is in the Mediterranean Basin, so is in certain danger of this threat. Under these predicted circumstances, many investigations were done, forward-looking goals and action plans were established and various projections were designed according to IPCC, The Vienna Convention, The Montreal Protocol, the United Nations Framework Convention on Climate Change (UNFCCC), the Kyoto Protocol and the Paris Agreement.

The Vienna Convention: This agreement was adopted in 1985 for the Protection of the Ozone Layer, and is particularly concerned with the reduction of ozone-depleting substances.

The Montreal Protocol: This protocol adopted in 1987 to control the use and production of ozone-depleting substances, is one of the most successful multilateral agreements on the environment. The Montreal Protocol which has 197-member countries is a milestone and a good example for the establishment of the UNFCCC. Türkiye was involved in this protocol in 1990.

United Nations Framework Convention on Climate Change (UNFCCC): This convention was submitted for approval at the United Nations Conference on Environment and Development (UNCED) (also known as the Rio de Janeiro Earth Summit) held in Rio de Janeiro, Brazil on 3-14 June 1992 and approved on 21 March 1994. The UNFCCC is important as it is the first environmental agreement on climate change at the intergovernmental level (Igci and Cobanoglu, 2019; Mazlum, 2019). In addition to 196 countries including Türkiye, the European Union (EU) is also a side to the convention. The aim is to encourage countries to reduce greenhouse gas emissions in the atmosphere, to cooperate on research and technology, and to protect greenhouse gas sinks (such as forests, oceans, and lakes). UNFCCC has two application tools: until 2020 the Kyoto Protocol after the 2020 Paris Agreement (MFA, 2023). Türkiye joined this convention on May 24, 2004.

Kyoto Protocol: The weakness of the sanction power of the UNFCCC caused a need for the implementation of a binding legal arrangement with more concrete objectives. The Kyoto Protocol to the United Nations Framework Convention on Climate Change was accepted in the COP-3 which was held on 1-12 December 1997 at Kyoto, Japan. The Kyoto Protocol came into force on 16 February 2005 (Igci and Cobanoglu, 2019). Türkiye was involved in the protocol on 26 August 2009.

Paris Agreement: This agreement, which sets the framework for the post-2020 climate change regime, was adopted at the 21st Conference of the Parties to the UNFCCC held in Paris in 2015. All countries globally committed to reducing their greenhouse gas emissions after 2020, for the first time, at COP-21. On 5 October 2016, at least 55 participants who meet the 55% of global greenhouse gas emissions signed the agreement then it entered into force on 4 November 2016., The Paris Agreement is the first global agreement to enter into force less than 1 year after its adoption. The Agreement aims to limit the increase in global average temperature caused by anthropogenic greenhouse gas emissions to well below 2°C above pre-industrial levels and to strive to limit the temperature increase to 1.5°C above pre-industrial levels.

Türkiye signed the Paris Agreement, which is a historical turning point in the fight against climate change, on 22 April 2016 and approved it with the Presidential Decree on 7 October 2021. Türkiye has set a target of reaching net zero emissions by 2053 (MEUCC, 2023).

4. GEOMATICS ENGINEERING ROLE FOR CLIMATE CHANGE MITIGATION

Geomatics is the union of the terms “Geo” and “matics”. “Geo” means land whereas “matics” means the mathematics and science used for studying the land. Geomatics acquire, manage, analyse, model and present the geo-spatially referenced information (HKPU, 2023). With the development of recent space-geodetic systems, the three characteristics of the Earth’s system, geometry, rotation and gravity field are possible to measure and monitor with high accuracy and resolution. More precise measurements and increased spatial and temporal resolution are possible with geodetic observations, which include variations in the surface of the solid Earth, the oceans, land surface waters, and ice sheets. These developments allowed geomatics to become a science that understands the Earth’s system and its dynamics which are directly related to climate change (Plag et al., 2010). Geomatics Engineering is a multidisciplinary field that provides measurement, mapping and spatial analysis by utilizing many current techniques, namely Remote Sensing, GNSS, Unmanned Aerial Vehicle (UAV), Geographic Information System (GIS), and Light Detection and Ranging (LiDAR). They have a very important role in guiding the studies to be carried out in mitigating the effects of climate change by being able to obtain and monitor the variables related to climate change in different dimensions and scales, quickly and reliably.

Remote sensing provides geo-information in spatial format and determines and monitors the Earth’s surface and subsurface capacity, unreachable areas by sensors and does this without the target contact. Satellite Remote Sensing (SRS) provides continuous global spatiotemporal information timely. SRS can measure data about the variables causing climate change such as greenhouse gases, glacier changes, clouds, aerosols, sea level changes, water and energy use, land use and land cover changes (Navalgund et al., 2007; Yang et al., 2013). SRS can collect valuable and unique data for especially unreachable and unmeasured areas. These data are independent and help us to understand, detect and solve the whole system from space. The most important component that will guide the climate change studies is the measurement of all effects that cause temperature increase. As the SRS continues developing it will continue studying and advancing SDG 13-Climate Action (Zhao et al., 2023).

It is not possible to know, understand, interpret and manage something that cannot be measured. When measurement, interpretation and management is a subject, the Geomatics Engineering discipline carries a very important role with its duty in the production and management of all kinds of geospatial data. To create accurate climate models and forecasts, scientists can use the geomatics discipline to collect, process, and analyse enormous volumes of spatial data (Matingo, 2023). GIS takes an important role in this frame while allows users to realize limitless analyses. The derived results can be serious inputs for the possible policies for related authorities.

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The accuracy of the data obtained from the analyses is proportional to the spatial data accuracy. All kinds of spatial data necessary for these procedures can be provided by the geomatics discipline with conventional terrestrial surveying techniques, LiDAR, UAV, Remote Sensing, GNSS, photogrammetry, and GIS techniques. The data can be derived in different forms as point or point clouds. All forms of the produced geospatial data are an important resource for climate change studies. Geomatics Engineers can determine the climate change parameters by the geospatial techniques easily, however, it is much more important the determine, mitigate and solve the causing effects of these parameters. Professionals in geomatics and geospatial fields are essential to comprehending and reducing these and other effects of climate change caused by humans (Sharma and Augustinus, 2023). The role of the geomatics discipline in climate change studies is tried to be outlined below based on different sectors.

4.1 Energy

Countries that have signed international agreements, develop policies to reduce energy consumption, meet energy needs from renewable energy sources, and reduce greenhouse gas emissions to ensure energy efficiency. In this way, countries that obtain their energy especially depending on fossil fuels are trying to reduce their external dependence. The important role of energy in the international relations of countries has been seen in many recent events. The building's energy-consuming activities such as heating, cooling and lighting, cause a total of approximately 39% CO_2 emission on an annual global scale with building materials (Figure 2) (Ahmed Ali et al., 2020).

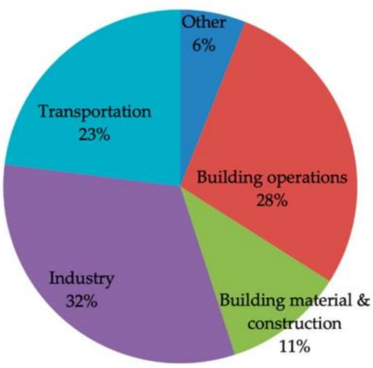

Figure 2. Global CO_2 emission by sectors (Ahmed Ali et al., 2020).

The most important reason for the gas emission amount is the use of coal. Agriculture, land use and waste (the effect of forest fires is ignored) rate was 20% while transport was 15% and buildings were 7%, respectively (Rivera et al., 2023).

CO_2 emissions from operational energy of buildings increased by around 5% in 2021 compared to 2020, reaching around 10 $GtCO_2$. Buildings generate about 27% of CO_2 emissions from operational energy. The increase in CO_2 emissions in the building sector shows that existing buildings are structurally quite inadequate for energy efficiency (UNEP, 2022). New buildings should be designed and constructed according to green building certification systems and existing buildings should be improved. Thus, energy efficiency improvements in these sectors will provide an important opportunity to reduce carbon emissions on a global scale. Additionally, in buildings, heat exits through air currents from all external elements such as walls, windows, roofs and floors. This heat loss can be detected by thermographic surveys and the energy efficiency improvement of the buildings can be realized. In addition to this many other details of the buildings can be obtained by 3D laser scanning measurements.

The Hydroelectric Power Plant Projects (HEPP) are the energy sources with the minimum CO_2 emission. HEPPs contribute equivalent to the oxygen provided by approximately 1.9 billion trees per year. Hydropower can be generated from reservoirs and rivers. Therefore, to utilise these water resources and protect them in a sustainable structure, it is necessary to measure and continuously monitor the related parameters. It is possible to take benefit of many geodesic measurements since the amount of energy to be obtained from water depends on the speed and amount of water moved, these parameters must be determined by both remote sensing and classical hydrographic measurements (Bieda and Cienciała, 2021). The rapid increase in water consumption in rural and urban areas damages the ecological balance. At this point, it is especially important to protect existing water resources in cities and to prevent leakage/loss of water during water transmission. It is possible to perform the possible measurements by the use of many different terrestrial and remote sensing techniques.

Solar energy as a renewable energy source is the richest of all energy sources and can be used even in cloudy weather. By 2050, the expected increase in renewable energy in the world is given in Figure 3. It is seen that solar energy will have the largest share in this increase (Simon, 2017).

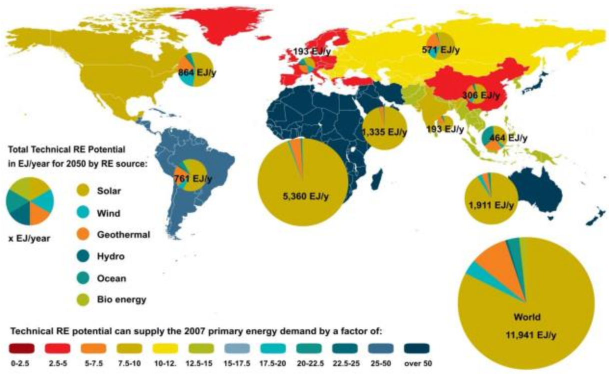

Figure 3. Renewable energy potential in EJ/year for 2050 by energy source (Simon, 2017).

With the solar roof cadastre concept, which has recently come to the agenda in many countries of the world, both the amount of solar energy that can be obtained from panels to be placed on the roof or garden of existing buildings and the capacity of photovoltaic installation of future buildings can be determined (Bieda and Cienciała, 2021). The solar energy potential can be modelled with 3D City Models built for settlements and the amount of energy needed to be provided by solar energy can be determined. In addition, Roof Surface Modelling and Visualization are also required for high-efficiency solar energy generation. Solar Energy Systems (SES) are not only used on land but also in water environments. It is possible to obtain energy by floating SES and the hydrographic data carry critical importance for these works. Another renewable energy source is wind energy, which generates energy by utilising the kinetic energy of moving air using wind turbines installed on land or in the sea/oceans. Solar Energy Cadastre, Wind Cadastre, Biomass Cadastre, Water Energy Cadastre, Geothermal Cadastre, and Marine Cadastre concepts began being an important part of the use of renewable energy sources (Michalak, 2018; Bieda and Cienciała, 2021; Cieślak and Eźlakowski, 2023). The renewable energy potential of related sources can be determined with the measurements carried out by the geomatics discipline. All of these works have a very significant role in developing strategies for replacing existing energy sources with renewable ones. In all these studies, the basic elements of the energy cadastre parameters can be measured using aerial/terrestrial techniques by using LiDAR and UAV surveys and GIS-based energy databases can be prepared. As a result of the renewable energy cadastre studies carried out by the geomatics discipline, 3D models, digital twins, etc. models are also created so that it is possible to consider not only the amount of sunshine in the region but also the effects of the shadows of other buildings in the study area. Some simulation scenarios carried out with particularly digital twins, have the potential to change climate resilience decision-making. The obtained models from simulation can simulate numerous climate-related issues, revealing potential vulnerabilities and required responses (Sharma and Augustinus, 2023).

On the other hand, while preparing the development (zoning) plans, energy efficient design approach must be considered and climate-resilient infrastructure should be created. Building Information Modelling (BIM) tools and green building certification systems can be used in the design, manufacturing and operation processes of buildings in order to construct sustainable, energy efficient and low carbon emission buildings. Reduction of heating/cooling energy costs should be ensured by creating natural air corridors at the development plan stage. Furthermore, it is essential to monitor Urban Heat Islands (UHI) and minimize their effects. UHI, leads to increased energy consumption especially during the summer season. This means the greenhouse gas emissions increase in cases the necessary electricity is derived from fossil fuels (note that every 0.6°C increase in air temperatures caused by the UHIs starting from 20°C-25°C results in a 1.5-2.0% increase in energy demand). It is reported that UHI in urban and rural areas increases average energy consumption by 5-10%. In determining urban development conditions and guiding constructions, some of the required energy should be obtained from renewable energy sources. In this context, the renewable energy potential of building roofs and gardens should also be considered as a parameter in planning. On the other hand, urban transformation/in situ transformation actions should aim to create a building stock with high energy efficiency. Surveying using Unmanned Aerial Vehicles (UAV)/Aerial LiDAR equipment will be a significant source of information for reducing losses in electricity distribution networks. Geomatics discipline is an inseparable component with the data it produces when the elements mentioned above are considered. In general, the use of 3D geo-data and geo-information technologies is essential for energy-efficiency management, and as a result, the cadastre of energy performance and energy potential will be prepared.

4.2 Transportation

Transportation holds a significant share, around 23%, in greenhouse gas production (see Figure 2 above). Reducing emissions from transportation is crucial in combating air pollution and climate change. Measuring the parameters necessary for determining the environmental impact of carbon dioxide emissions from transportation and managing them within an information system are essential. Creating transportation emission databases in cities and main transportation arteries and making necessary regulations will play an important role in this process. Remote sensing, LiDAR and GIS technologies will be important tools for decision-makers in these studies. Geomatics discipline can be beneficial in creating traffic density maps and suggesting alternative smooth routes when navigating.

4.3 Urbanization

Human activities causing global warming are particularly widespread in cities. Therefore, cities are vital for the success of climate change studies. Currently, the world's population has reached approximately 8.1 billion people, with 55% living in urban areas globally. This ratio is estimated to reach 68% by 2050. Considering that cities are responsible for 70% of global greenhouse gas emissions (Asici, 2017), environmental studies, especially those related to climate change, must focus on cities. Geomatics discipline is capable of measuring the greenhouse gasses in the atmosphere via satellite data. The components or the reasons causing the greenhouse gasses can also be measured by geospatial techniques. All the measured data can be evaluated by GIS and serve the local governments for the improvements. Geomatics technologies are critical tools for tracking and managing factors affecting climate in this process.

4.4 Agriculture and Forestry

Forests play a key role in combating global climate change. For instance, a tree can absorb between 10 to 40 kg of CO_2 per year depending on various factors. Wetlands also play a significant role in global climate change through the capture and release of atmospheric carbon. Particularly, peatlands and forested wetlands are crucial as being important carbon sinks and should be protected and, if possible, expanded. A system for monitoring wetlands should be established. Strategies for determining, protecting and increasing the sink area capacities of cities should be developed. Inventory of the existing vegetation in the region should be carried out to determine water consumption and greenhouse gas emissions. Water basins and sources should be closely monitored, riverbeds should be rehabilitated. The amount of evaporation of water sources such as lakes/ponds/dams should be determined and pollutant elements should be identified and monitored. It should be monitored whether there is pollution in the water sources where drinking water needs are met. Sustainability activities for dams should include regular dredging to continue their operations. Agricultural lands, forests, and pastures, which are crucial for humans, should be preserved. In this context, undeveloped or uncontrolled constructions on agricultural lands should not be allowed. It is possible to utilise many geomatics applications such as aerial techniques and hydrographic measurements in the stated studies. Geomatics applications can contribute significantly to managing this process with the products they produce.

In agriculture, UAV, GNSS, satellite imagery data can be used in "Precision Agriculture" applications to optimize crop management, reduce water consumption, and minimize pesticide and fertilizer use. Additionally, inventories of fertilizer consumption can be prepared to make necessary improvements in fertilizer use. This approach increases agricultural productivity while reducing environmental impacts (Matingo, 2023). A changing climate, desertification, and land degradation will all cause agricultural systems to be disrupted and crop production to fall. The lack of water will only get worse (Sharma and Augustinus, 2023). Inventories of agricultural

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waste and residues should be conducted. Effective monitoring and prevention of the commonly practiced burning of crop residues can be achieved through satellite-based systems like remote sensing, and aerial techniques. It is also necessary to prepare current, detailed international standard soil maps. Efforts should be made to develop and operationalize prediction and early warning systems for drought, floods, forest fires, and landslides. All the aforementioned studies can be conducted using conventional terrestrial, aerial/remote sensing, and satellite-based techniques, which are typical applications of the geomatics engineering discipline.

5. CONCLUSIONS

The adverse effects of climate change threaten not only humanity but also the essential elements of other living species to exist on the Earth. Global and national awareness should be settled in combatting climate change. In this framework, all relevant disciplines must focus on the solution of problems related to climate change with a common awareness and unity of action, and carry out the necessary work to reduce and, if possible, eliminate the possible negativities which is partly necessary for the concept of engineering ethics. Geomatics Engineering would make the most important contribution to the studies for understanding the future climate patterns, adaption and mitigation strategies for climate changes and establish the monitoring system for climate-related phenomena and others with an interdisciplinary approach. Many products (i.e. geospatial data, map/chart, point clouds, model, etc.) that enable spatial analysis obtained from measurements made by geomatics engineering using geomatics technologies such as aerial survey, satellite imagery, GNSS, LiDAR, and UAV will serve as a very important source of information for decision-makers and public authorities in strategy development, land management and ecosystem restoration. As stated above, Geomatics Engineering as a main geospatial data producer is either directly involved in the studies to be carried out within the framework of combating climate change, or makes significant contributions to the management and monitoring of these processes through the products it produces, and develop effective strategies to mitigate climate change impacts. To effectively design and implement strategies for lowering greenhouse gas emissions, we must have a worldwide understanding of the causes and implications of climate change. This is where geospatial technology plays a significant role in mitigating climate change. We can obtain invaluable insights into emission sources worldwide by employing remote sensing techniques like satellite imagery analysis in conjunction with GIS mapping tools and other data sets (e.g., population density). These insights will help us make well-informed decisions about how best to reduce emissions going forward, ultimately leading us toward a more sustainable future. In line with the developments in geospatial data collection and analysis methods of the geomatics field, they will assume more pioneering and important roles in climate change studies in the future.

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