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Status of Spatial Data Construction for Climate Change Mitigation and Adaptation in Central Asia

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ABSTRACT

The importance of spatial data is rising as a means to reduce vulnerabilities and risks associated with climate change. Considering the recognition of its importance, many developing countries are struggling with capacity building for spatial data construction. The key objective of this study is to understand the current status and challenges of spatial data construction in Central Asian countries with a focus on enhancing the use of spatial data in Central Asian countries through international cooperation. The target countries are Azerbaijan, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan. This research used the official data provided on the websites of cartography agencies in Central Asia countries as well as data presented at regional workshops on the integration of statistical and spatial data in Central Asia, which was conducted by the United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP). The collected data are classified into three types: fundamental maps, thematic maps and NSDI (National Spatial Data Infrastructure). Through this classification, analyses of the resolution level and the data-sharing system were conducted. The results show that each country exhibits differences in spatial information capabilities. In the case of Kazakhstan and Uzbekistan, satellite data produced by the aerospace agency are actively used for land management, focusing on the ecosystem. However, other countries mainly rely on statistical data to manage the land, and it is found that spatial data are not actively utilized. In addition, Kazakhstan and Uzbekistan have implemented the NSDI over the past years, which facilitates the sharing of spatial data. However, the rest of the countries in Central Asia show limitations in terms of sharing geospatial data, and additionally lack data infrastructure. This paper reveals the differences in national competency when using and managing geospatial data among Central Asian countries. The results of this analysis will contribute to building future policies and actions, acting as a reference for improving the national capacity, relevant infrastructure, and regional-international cooperation.

Key words: *Climate Change Adaptation, Sustainable Development, Geospatial Data, Cadastral Map, NSDI*

1. Introduction

Climate change mitigation and adaptation have been one of the big issues for many countries around the world and most of them made efforts to reduce green gas emission for a long time (Grafakos et al., 2020). After the

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Paris agreement, IPCC (Intergovernmental Panel on Climate Change) published 'The Special Report on Global Warming of 1.5 °C' (SR15) in 2018 and urged that more intensive action should be conducted to mitigate the drastic climate change impact. The report insisted that "limiting global warming to 1.5 °C compared with 2 °C would reduce challenging impacts on ecosystems, human health and well-being" and that a 2 °C temperature increase would exacerbate impacts of climate change. To mitigate climate change impact, both man-made properties and natural resources are needed to be managed statistically (Vardon et al., 2019). As well, proper adaptation measures are required to manage the vulnerable area, such as where have flood risk or heatwave problems.

Spatial data has been used for the assessment of vulnerability in various fields related to climate change, so they could manage natural resources effectively. In addition, in terms of disaster preparedness, spatial data can help to detect disaster-prone areas before they occur, apply management measures to the right places, and minimize damage by establishing a prediction system (Giardino et al., 2012). Thus, the integration of statistical data and spatial data would make better implementation of natural resource management policy to respond to climate change (Harris et al., 2017).

In this point of view, the UN (United Nations) developed SEEA (System of Environmental Economic Accounting) that provides the framework for producing comprehensive statistics on the economy and the environment (La Notte et al., 2019). The framework suggests the application of spatiotemporal data to quantitatively assess the environmental factors. Through this framework, natural resources can be managed quantitatively in the way of integrating biotic and abiotic. (Choi et al., 2014). Even though the importance of quantitative assessment of natural resources is emphasized throughout the world, the abilities to implement such a scheme on a national scale are different between countries according to their level of spatial data construction. Globally, these gaps have worsened the overall effectiveness of climate change mitigation and adaptation actions.

Developed countries recognized the importance of spatial data and related infrastructures early. Therefore, they have constructed spatial data managing infrastructure and developed the techniques for production, application and sharing of spatial data (Nikolina Mijić and Šestić, 2018). The U.S.A., European countries and Japan developed and applied GIS (Geographic Information System) in the early 1960s to build an effective land management system. They also constructed spatial data open platforms to vitalize the availability of spatial data (Scott and Rajabifard, 2017). Even though developing countries have also produced spatial data for decision making on natural resource management, they still have many issues on using spatial data such as distribution matters in their countries, lack of knowledge, shortage of professional technicians and so on (Astsatryan et al., 2012).

Among developing countries, Central Asia countries have been continuously supported by international cooperation projects and ODA (Official Development Assistance) to develop spatial data infrastructure and strengthen institutional capacity. However, GEOBUIZ Annual Report published by GMC (Geospatial Media and Communications) determined the rank of Central Asia countries and they were placed at the lower part among other developing countries. Kazakhstan was ranked 47th, Azerbaijan was 66th and Kyrgyzstan was 66th in 2019 (Geobuiz, 2019). It means some limitations on the application of spatial data are remain in those countries (Arazmuradov, 2011).

After the collapse of the Soviet Union in the early 1990s, it was a very short term for Central Asia countries to implement their economic development policy. Besides, economic depression which caused the breakup of the Soviet Union has was an obstacle for the development (Lioubimtseva and Henebry, 2009). This background made it hard to develop institutional spatial data capacity. Since such limitations cannot be solved by self-exertion, developed countries or international organizations should support them under international cooperation projects. Therefore, this study aims to investigate the status of spatial data construction and verify the weaknesses of each country to give fundamental information for international cooperation that will be conducted in the

future.

2. Method & Material

2.1 Study Area

Central Asia is extending from the border of western China and southern of Russia to the Caspian Sea. This region occupies the interior land of the Eurasian continent and it makes the moist air from the sea hard to reach this region. So more than 93% of the total area is dry land, and the ecosystems of this region are very sensitive and susceptible to climate change (Yu et al., 2020). Furthermore, Aral Sea has been recently dried up due to the development of dams on its branch, Amu Darya and Syr Darya. Water reduction in the Aral Sea is accelerating climate change in Central Asia.

Azerbaijan, Kazakhstan, Kyrgyzstan, Uzbekistan, Tajikistan and Uzbekistan were chosen for the study area because they were considered vulnerable to climate change impacts due to their dry climate. As climate change impacts grew stronger, various international cooperation projects had been implemented. For an instance, study area countries participated in the project of UNESCAP (United Nations Economic and Social Commission for Asia and the Pacific) to develop the construction of spatial datasets for climate change mitigation as members of the commission in the UNESCAP. Through the project “strengthening institutional capacity on integrating geospatial and statistical data, with a focus on land accounts in Central Asia”, a regional inception workshop on integrating statistical geospatial data for land accounts and statistics in Central Asia was held in Tashkent, Uzbekistan from 14 to 15 November 2019 (Fig. 1).

2.2. Method

Information related to spatial data status in the Central Asia region was collected from researching official reports of the cartography department and international cooperation project reports through the online and preceding research. Collected data were classified into three subjects, fundamental map, thematic map and NSDI. In each subject, the country statuses were analyzed and weaknesses could be found. According to the found, this research can suggest proposals that are appropriated to each country and give useful information for future international cooperation projects (Fig. 2).

Fig. 1. Research areas in the Central Asia Region.

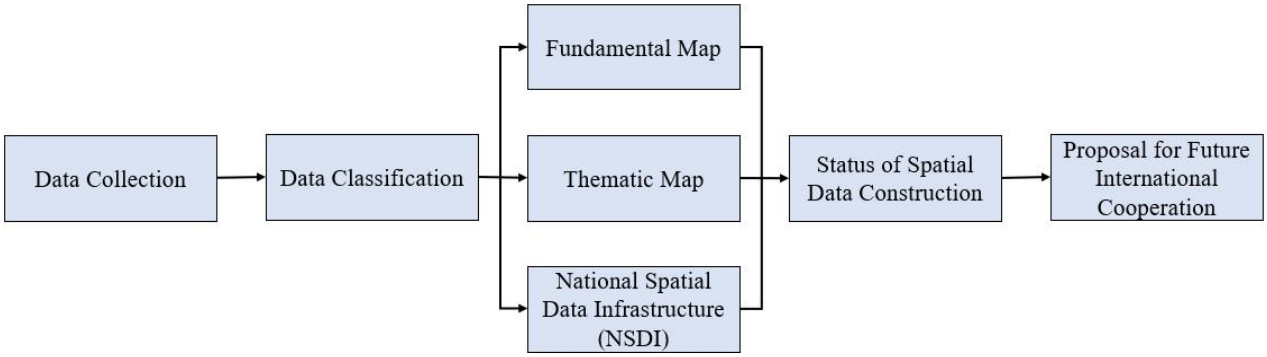

Fig. 2. Research steps for analyzing the status of spatial data construction in Central Asia countries

The orthophoto map, cadastral map and topographic map were considered as fundamental maps. The orthophoto maps are simply understood as true color maps but they are revised to correct the tilt or any other errors that occurred when they are photographed by satellite or airplane (Novak, 1992). Cadastral maps provide information on location, type, ownership and address of land which is typical spatial data for land management (Williamson and Enemark, 1996). Topographic maps generally include topographic reference data considering themes and feature types. These databases give structured reference data of land on the national level (Kent and Hopfstock, 2018). The essential conditions on the spatial data construction were verified by investigating these three fundamental maps.

The maps were categorized into two kinds. One is a fundamental map that is above mentioned and the other is thematic maps. Thematic maps can be used in natural resources management for climate change impacts mitigation and adaptation. This research tried to find thematic maps on natural resources and disaster information in study area countries to identify spatial data as a means of mitigating and adapting the climate change.

The last criterion for data classification, NSDI, was started to be built in the 1990s by the U.S.A and the function it has been developed for efficient managing spatial data on the national level. Today, NSDI is defined as a framework of policies, institutional arrangements, technologies, data, and people that enable the sharing and effective usage of geographic information by standardizing formats and protocols for access and interoperability (Čada and Janečka, 2016). Based on this concept, the spatial data availabilities of study area countries were assessed by the establishment of NSDI.

2.3 Material

In this study, most of the information was collected from the cartography or land management agency of each country. These agencies have produced cadastral maps, topographic maps and various thematic maps. They are operating the official website and official information on production, distribution and availability of spatial data can be gathered through those websites (Table 1).

However, a lot of spatial data in Central Asia was constructed by international cooperation projects. Thus, additional information was found through the reports of previous projects conducted to improve their institutional capacities.

The investigation was implemented online and it had limitation that some information was not shared through the website. To overcome this limitation, the reports of international cooperation project that Central Asia countries had participated with other international organizations. Developed countries also were the main partners this research focused on.

3. Results

3.1 Current Status on Fundamental Maps of Central Asia

Azerbaijan and Uzbekistan had digital orthophoto maps and their scale was open to the public, but there was no

information on the production or sharing of orthophoto maps in others. Cadastral maps and topographic maps were verified that they were produced by mapping agencies of Central Asia countries even some of the details were not verified. Cadastral maps were databased in every country except Tajikistan and digital topographic maps were not available to see in every country (Table 2).

Table 1. Mapping agency of Central Asia countries

Nation	Agency	Website
Azerbaijan	The State Committee on Property Issues, Ministry of Ecology and Natural Resources, Ministry of the State Border Service	http://emlak.gov.az http://eco.gov.az http://www.dsx.gov.az
Kazakhstan	Agency for Land Resources Management	http://www.kazlands.kz
Kyrgyzstan	Agency for State Resources	http://gkpen.kg
Uzbekistan	National Center for State Cadastres, Geodesy and Cartography	https://ygk.uz
Tajikistan	State Committee for Land Management and Geodesy	https://zamin.tj
Turkmenistan	The Department of Land Cadastre in the Service of Land Resources under the Ministry of Agriculture	http://minagri.gov.tm

Table 2. Construction status of fundamental maps

Nation	Orthophoto map	Cadastral map	Topographic map	Database
Azerbaijan	Urban 1:2,000 1:8,000 Rural 1:5,000 1:20,000 (FIG, 2020)	O (FIG, 2020)	O (eurogeographics, 2020)	Cadastral map (36% completed) Topographic map (Unidentified)
Kazakhstan	Unidentified	Urban 1:2,000 1:2,500 (Myrzagaliev, 2019)	O (Alipbeki et al, 2020)	Cadastral map (Completed) (URL: geoportal.kz) Topographic map (Unidentified)
Kyrgyzstan	Unidentified	Agriculture site 1:10,000 (Karypov, 2015)	1:25,000 1:100,000 (JICA, 2006)	Cadastral map (Completed) (URL: geoportal.kg) Topographic map (Completed)
Uzbekistan	National 1:25,000 1:200,000 Urban 1:500 1:2,000 1:10,000 (Lee, 2018)	O (Makhsudov, 2015)	National 1:25,000 ~ 1,000,000 Urban 1:1,000 1:2,000 (Lee, 2018)	Cadastral map (Completed) (URL: geoportal.uz) Topographic map (Unidentified)
Tajikistan	Unidentified	1:10,000 (UNECE, 2011)	Urban 1:5,000 Agriculture 1:10,000 1:25,000 (UNECE, 2011)	Cadastral map (Unidentified) Topographic map (Uncompleted)
Turkmenistan	Unidentified	1: 5,000 (Hyunil and Handon, 2012)	1: 5,000 (Hyunil and Handon, 2012)	Cadastral map (Completed) Topographic map (Completed)

O: Data exists, but specific information is not provided

The State Committee on Property Issues, Ministry of Ecology and Natural Resources and Ministry of the State Border Service were responsible for the management and production of urban cadastral mapping in Azerbaijan. The cadastral map of Azerbaijan was completed by about 36% so far in 2018 through cooperation with FIG (International Federation of Surveyors) and will be completed by 2020 (FIG, 2020). It was currently not possible to check whether topographic maps are databased. The specifications of the orthophoto maps were 1:2,000 and 1:8,000 for urban areas and 1:5,000 and 1:20,000 for rural areas. The detailed information on cadastral and topographic maps could not be found.

In Kazakhstan, the Agency for Land Resources Management was in charge of mapping and management. 1:2,000 and 1:2,500 scale cadastral maps were produced for urban areas. Although it was mentioned that the topographic maps were built on a national scale, it was not possible to identify specifications or maps. Databased maps can be accessed on the website of Kazakhstan's Land Management Bureau without any restrictions. Kazakhstan operates its platform for sharing a cadastral map, but it was not translated into English and also had no download function.

Kyrgyz State Service of Geodesy and Cartography was a mapping department in Kyrgyzstan and it manages the spatial data. The scales of topographic maps were in the range of 1:10,000 to 1,000,000. The cadastral map of the agricultural region was established in a 1:10,000 scale and the urban cadastral map can be found on the state-run Kyrgyzstan cadastral map website. The information provided on the website is available only in its language and the website does not have a download function.

In Uzbekistan, The State Committee of the Republic of Uzbekistan for Land Resources, Geodesy, Cartography and State Cadastral was in charge of enactment on spatial data policy, and the National Center for Geodesy and Cartography was in charge of mapping service. The scales of Uzbekistan's topographic maps were 1:25,000 to 1:1,000,000 and a cadastral map was provided by Geoportal that can be used by anyone online. However, the website didn't have translate and download functions likewise the cases of Kazakhstan and Kyrgyzstan.

State Committee for Land Management and Geodesy had responsibility for producing and managing maps in Tajikistan. The scale of the cadastral map was 1:10,000 and topographic maps had three types. 1:10,000 and 1:25,000 scale for agriculture region, and 1:5,000 scale for Urban region. Tajikistan was not operating a website that shares spatial data around the country.

The map producing and managing the department of Turkmenistan was the Department of Land Cadastre in the Service of Land Resources under the Ministry of Agriculture. Even Turkmenistan had a department related to spatial data, it had a problem with the lack of funds and human resources. Besides, there was little information on this department, so it was difficult to verify the status of Turkmenistan.

3.2 Current Status on Thematic Maps of Central Asia

Orthophoto maps, cadastral maps and topographic maps were fundamental spatial data that were deeply related to the production of various thematic maps (Cichocinski, 1999). The reason for using thematic maps was to manage resources and the environment by focusing on specific subjects. Certain thematic maps can be used to cope with climate change impacts by identifying time-series changes. Kazakhstan and Kyrgyzstan databased more than 50% of thematic maps but most of the thematic maps in the other countries were still made with paper. It was also difficult to find regional-scale maps that contained more detailed information than national-scale maps (Table 3).

Azerbaijan produced ecology map, 1:100,000 soil map, and 1:500,000 forest map concerning the natural environment. Ecology map show the habitats of various animals and the locations of conservation subdivisions. Soil map contain the information of arable lands, agro-climatic zone, soil salinity, erosion, etc. In case of the forest map, it present 7 different forest types. The map of flood, fire, earthquake, and landslide risk were produced, but they were so simple that those maps only divide the risk level into three stages, low, middle and

Table 3. Thematic Maps of Central Asia

Nation	Thematic maps	Scale	Database	Source
Azerbaijan	Soil maps	National	×	(ISSA, 2020)
	Forest map	National	×	(MENR, 2019)
	Disaster maps (flood, wildfires, earthquake, landslides)	Regional	○	(PPRD East 2, 2016)
Kazakhstan	Land use map	National, regional	○	(Shokparova, 2019)
	Agro-climatic indicators	National, regional	○	(Shokparova, 2019)
	Soil maps	Regional (1:500,000)	×	(LPP, 2005)
	Drought monitoring	National	○	(JSC, 2018)
Kyrgyzstan	Landscape map	National (1:3,000,000)	×	(NWRMP, 2017)
	Forest map	National (1:3,000,000)	×	(NWRMP, 2017)
	Land use map	National (1:3,000,000)	×	(NWRMP, 2017)
	Landslide map	Regional, National (1:3,000,000)	×	(NWRMP, 2017)
Uzbekistan	Land use map	Regional, National	○	(UZGIP, 2009)
	Soil salinity map	National	○	(WOCAT, 2018)
	Land degradation map	National	○	(WOCAT, 2018)
Tajikistan	Geological map	National (1:500,000)	×	(Geoportal, 2020)
	Hydrogeological map	National	×	(Geoportal, 2020)
	Ecosystem map	National	×	(Safarov, 2003)
Turkmenistan	Pasture map	National (1:200,000)	×	(UNECE, 2012)
	Ecosystem map	National (1:200,000)	×	(UNECE, 2012)
	Air and water monitoring map	National (1:200,000)	×	(UNECE, 2012)
	Land degradation map	National (1:200,000)	×	(UNECE, 2012)

high (PPRD East 2, 2016). The maps mentioned above were produced within five years and were used as materials for resource and environmental management, and disaster preparedness.

Kazakhstan used land-use data and crop production data managed by the national economic and statistical departments at national and regional levels and conducted environmental monitoring with climate information such as precipitation, temperature and evaporation levels through its satellite images. Kazakhstan's Kashydromet website provided information that was not only numerical but also visualized on maps. Various resources such as soil and minerals were also databased as spatial data. However, most of the data were used only within the Kazakh government and the sharing to the private sector was blocked.

Uzbekistan had 21 thematic maps but, it was not possible to find all the thematic mpas through the website. In addition, it was also difficult to find the maps which contained the information related to climate change

mitigation and adaptation. The three thematic maps found in this research were databased but they were not able to be shared online.

Kyrgyzstan had six main forests formations. These six forests were Schrubs, walnut broadleaved, juniper, spruce and pistachio. Land use map had information on arable land, pasture, forest and any other environmental places without urban. Landslides map showed five different levels of areas that were susceptible to landslide in national and regional scales. At last, landscape map was focused on the type of land so its legend had desert, steppe, meadow and so on. These maps were produced through the world bank project that made national water resource management platform in 2017 and provide the data on its website. However, the website only provide the picture of the thematic maps and it was not possible to access the database (NWRMP, 2017).

Tajikistan and Turkmenistan also had ecosystem maps that show the land types same as other countries's maps. The maps of Tajikistan were made to support the mining industry and ecosystem map was old map produced in 2003. In case of the Turkmenistan, the thematic maps could be found from the environmental performance review report of UNECE that was published in 2012, so there was only outdated information and also no more details than the image (UNECE, 2012).

3.3 Current Status of NSDI in Central Asia

The objectives of NSDI were to reduce duplication of efforts among governments, lower costs related to geographic information while making spatial data more accessible, increased the benefits of using available spatial data, and established key partnerships between states, counties, cities, academia, and the private sector. NSDI should be considered as part of wider e-Government initiatives (Tonchovska et al., 2012). Central Asia countries had been announcing plans to enact and implement laws for the establishment of NSDI to promote the use of spatial data and three countries constructed NSDI through the supports of international cooperation projects (Table 4).

Azerbaijan planned to hold the international conference "National Spatial Data Infrastructure: Towards a Digital Society" in the Baku region from April 2 to 4, 2020, but it had been extended indefinitely due to the COVID-19 crisis. Several international organizations, including UNECE (United Nations Economic Commission for Europe), World Bank, FAO (Food and Agriculture Organization) and UN-GGIM (United Nations Global Geospatial Information Management), were expected to discuss the construction of NSDI in Azerbaijan, led by the State Service on Property Issues department under the Ministry of Economy of the Republic of Azerbaijan (UNECE, 2020). Although this conference had not been held, the presentation from Conference "Digitally Enabled Development for a Sustainable Future in Eastern Europe" indicated that Azerbaijan was now in need of establishing a project management committee, professional task teams and system construction plan (SCPI, 2019).

Table 4. Status of NSDI in Central Asia

Nation	NSDI	Plan	Participated Agency
Azerbaijan	○	○	
Kazakhstan	○	○	KRIHS (Korea Research Institute for Human Settlements)
Kyrgyzstan	×	○	
Uzbekistan	○	○	KLIS (Korea Land Information Corporation)
Tajikistan	○	○	UNDP (United Nations Development Programme)
Turkmenistan	×	×	

Kazakhstan was now moving beyond producing fundamental maps and trying to apply the spatial data platform to policies along with the establishment of a land information system. The Kazakhstan government was establishing a platform with the assistance of international cooperation to integrate 290 information systems. Through this development, those separated systems will

automatically produce and share various data based on the platform. The NSDI development plan of Kazakhstan also focused on the integration of existing spatial data, so the platform will serve its function as a part of NSDI. Therefore, the plan for NSDI development in Kazakhstan was the integration of the several spatial data platforms, construction of short-term spatial data update system and law revision to open their private spatial data into the public (Tuleubayeva, 2019).

Kyrgyzstan planned policies for the establishment and development of NSDI from 2015 to 2020 and prepared legislation to create cooperation among agencies related to the establishment of NSDI in 2014. Under the ACR (Automated Cadastral System) and the cadastral database, it intended to lay the foundation for the establishment of NSDI to strengthen links in several resource management departments such as the agriculture and forestry department. Kyrgyzstan developed the working group for a draft strategy for the NSDI development in 2015 and they have worked on it. For the next step, they needed to determine and make standardization of spatial data, develop geodetic network and make legal framework for advanced NSDI after the development (Karypov, 2015).

Uzbekistan implemented the NSDI master plan projects from 2016 to 2018 as a cooperative project with the Korea Land Information Corporation. Based on this project, Uzbekistan will carry out modernization projects in the future. Thanks to such international cooperation, the government developed a national and regional land information system and developed the USSC (Unified System of State Cadastre) to manage national cadastre-based information. However, the topographic maps were still managed by various departments without a discussion on integration and data standardization. For the plan of NSDI development, they needed to construct a system that makes the people share spatial data and unify the distributed spatial data to manage integrated ways (Imamkulov, 2019).

Tajikistan began to establish NSDI in 2008 with the support of the UNDP. In 2017, there was a news that the Head Department of Geology of the Government of Tajikistan established NSDI with the support of organizations such as the SDC (Swiss Agency for Development and Co-operation), AKFUK (Aga Khan Foundation United Kingdom), and ECHO (European Union Civil Protection and Humanitarian Aid Operations). However, there was no more significant information on the development of NSDI in Tajikistan so far. After the development of NSDI with UNDP, they were tried to upgrade it by integrating the spatial data and developing data standards so, these objectives could be considered for the plan of NSDI in Tajikistan (UNDP, 2013).

Turkmenistan is working with KOICA (Korea International Cooperation Agency) on a project to build intellectual information infrastructure, but there was no verifiable information on the plan to build NSDI. Currently, it seemed that the government could not carry out policies related to sharing spatial data across the country because Turkmenistan was focusing on the establishment of a land management system with the supports of ODA projects. For Turkmenistan, the establishment of the other platforms or systems for spatial data would give help for the development of NSDI in near future or they need to enact the law for NSDI plan for the first step if they need to make a more apparent plan.

As mentioned above, three Central Asia countries established NSDI, but they didn't have an integrated management system or NSDI portal for spatial data. Fundamental maps and thematic maps should be managed on this system but, they were still developing their system and needed more time to make NSDI contribute to better spatial data circumstance. Nevertheless, Kazakhstan, Kyrgyzstan and Uzbekistan were operating cadastral map portals, and those systems can be the foundation for future NSDI.

4. Discussion

Climate changes occur in the complex context of nature and their results cause various environmental or social problems such as extreme weather, climate disasters, losing biodiversity. To prevent these impacts, policy decisions should be conducted by covering intricate interactions of nature and it requires prompt detection of

climate and environmental changes. In this context, analysis based on spatial data must be implemented and international organizations have made diverse frameworks and initiatives for climate change mitigation and adaptation considering this requirement.

In the mitigation aspect, the use of geospatial data is necessary to develop environmental-related carbon sequestration projects. For instance, A/R CDM (Afforestation and Reforestation Clean Development Mechanism) and REDD+ (Reducing Emissions from Deforestation and forest Degradation, and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries) require monitoring, reporting and validation processes to know the project area where suffered deforestation and the amount of carbon sequestration (UNFCCC, 2020). These projects require the national or regional capacity to handle geospatial data, so the central Asian countries need the capacity to have more active projects. Therefore, knowledge sharing through international cooperation in the geospatial sector can help the developing countries' local needs to meet the global mitigation agenda.

Likewise, the reduction activities of greenhouse gases should be reported by countries to UNFCCC (United Nations Framework Convention on Climate Change) under the Paris agreement. Spatial datasets that investigated in this study also can be used in the various assessment of national inventory as well as building LULUCF (Land Use, Land Use Change and Forestry) system. In addition, tier and approach levels of national estimation on GHG (Greenhouse Gas) emissions highly depend on using spatial data. Especially, the cadastral maps are the fundamental factors to make a report of the LULUCF sector and conduct NFI (National Forest Inventory) by confirming the parcel of land (Park et al. 2018).

In the adaptation aspect, various thematic maps are necessary for diverse subjects. In Korea, vulnerability assessments have been conducted using these thematic maps and the results have been reflected to establish climate change adaptation plans of governments. With these spatial data analyses and assessments, governments also can construct emergency response systems responding to disasters such as floods or drought, and the public can be informed in an urgent situation (Yeon et al., 2018; Jung et al., 2020). Topographic maps are also vital to analyze land-use change, water resource, disaster and so on (Kang et al., 2010). If such a spatial dataset has accumulated for a long period, time-series analysis to predict future climate change impacts is possible (Qiu et al., 2020).

Regarding these cases, constructing and accumulating spatial data, operating management systems of those data, and increasing utilization contribute to responding to climate change and reducing its impacts. In developing countries, the infrastructure facilities are incomplete or insufficient compared to developed countries. When attempting to build these infrastructures at the government or international cooperation level, climate change, environment and disaster vulnerability assessments, which significantly depend on spatial analysis should be conducted. In this context, the statuses of the spatial data construction in Central Asian countries were reviewed and several implications were found.

Kazakhstan, Kyrgyzstan, and Uzbekistan have operated Geoportal that makes high accessibility on the cadastral map, but DB status was only verified in the rest of the countries through literature research. It was not possible to download or verify all the spatial data online. Most of Central Asia countries did not have the interoperability infrastructure to increase the usability of spatial data on a national level. The countries, except Kazakhstan and Uzbekistan, remained at the level of preparing plans and decrees for the establishment of NSDI. Although Kazakhstan and Uzbekistan established NSDI, they still have issues of data standardization and integration between various departments alike status of fundamental maps and thematic maps. It shows that spatial data of Central Asia countries have not been shared actively and it is hard to expect that they are using the existing spatial datasets successfully for mitigation and adaptation on climate change (Maguire and Longley, 2005).

In developed countries, they integrated all services related to spatial data based on NSDI and are now

improving its functions for their citizens' convenience. As well, they are focusing on building automatic processing for greater transparency and access (Tonchovska et al., 2012). As the process of NSDI establishment, Central Asian countries need to build a spatial data platform to integrate dispersed data as developing countries have done. In this part, they need to learn the experiences and technics of developed countries through international cooperation projects.

Even though the issues of spatial data construction in the study area were identified, the study has some limitations that the investigation was conducted based on literature which was only available online. Therefore, the information that may exist offline could not be reflected in this study. As mentioned in the results, some reports of the government agency and international cooperation projects are not available online, and some countries do not open specific details about data to the public. Moreover, status research on private companies in Central Asian countries has not been conducted. However, the advantage of collecting data online is that it is possible to understand the utilization of the data in a certain country. In the case of data that can be easily accessed online, it implies that the level of utilization and sharing of it is high. Moreover, such investigation on various spatial data can make understand the overall level of spatial data sharing throughout the country. In addition, this research complemented the limitation of online investigation by searching the project reports which were implemented with other international organizations and developed countries for development of spatial data construction in Central Asia. Based on this concept, this study provides the fundamental information of Central Asian countries' status on the construction of spatial datasets and their current issues and weaknesses of spatial data that need to be considered for future international cooperation projects.

5. Conclusion

Climate change mitigation and adaptation require to use the spatial dataset due to the extensivity of climate change impact. However, the application of spatial data on managing natural resources depends on the institutional capacity of specific countries. So, the different levels between strengthening capacity and deteriorating extreme climate change conditions make developing countries difficult to adopt proper measures on responding to climate change.

Developed countries have developed NSDI for the efficient use of spatial data, and related policies are being implemented to systematically build digital spatial information and integrate it with information and communication technology. Their experiences can give developing countries chances to improve the capacity of using spatial data and overcome limitations such as lack of funds, time, and professional manpower, therefore Central Asian countries have to implement spatial information policies by learning the experiences and skills of developed countries through international cooperation projects.

Through this study, the suggestion of this research is that various international cooperation projects are needed to be implemented for these countries. The aid such as technology transfer, professionals training and support for NDSI construction will increase the capacity of spatial data application in managing natural resources. Besides, the benefits of international cooperation will not only provide opportunities for aid recipients but also contribute to enhancing economic performance by increasing the chances of donor companies entering foreign markets. Eventually, the goals of sustainable development will be achieved through these collaborative works that contribute to climate change adaptation and mitigation on a global scale.

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References

Alipbeki O, Alipbekova C, Sterenharz A, Toleubekova Z, Aliyev M, Mineyev N, & Amangaliyev K. 2020. A Spatiotemporal Assessment of Land Use and Land Cover Changes in Peri-Urban Areas: A Case Study of Arshaly District, Kazakhstan. Sustainability, 12(4), 1556.

Arazmuradov A. 2011. Foreign aid, foreign direct investment and domestic investment nexus in landlocked economies of Central Asia. (1):129–151.

Astsatryan H, Narsisian W, Ghazaryan V, Saribekyan A, Asmaryan S, Muradyan V, Guigoz Y, Giuliani G, Ray N. 2012. Toward to the Development of an Integrated Spatial Data Infrastructure in Armenia. ICT Innov.:85–92. http://ictinnovations.org/2012,.

Čada V, Janečka K. 2016. The strategy for the development of the infrastructure for spatial information in the Czech Republic. ISPRS Int J Geo-Information. 5(3). doi:10.3390/ijgi5030033.

Central Asian Countries Geoportal of Tajikistan. 2020; [accessed on 2020 April 19]. http://www.geoportal-tj.org/

Choi H-A, Lee W-K, Song C, Lee JY, Jeon SW, Kim JS. 2014. Applicability Analysis of Water Provisioning Services Quantification Models of Forest Ecosystem. J Korea Soc Environ Restor Technol. 17(4):1–15. doi:10.13087/kosert.2014.17.4.1.

Cichocinski P. 1999. Digital cadastral maps in land information systems. Lib Q. 9(2):211–221. doi:10.18352/lq.7535.

Eurogeographics. 2020. Real Estate Cadastre and Address Registry Service under the State Committee on Property Issues, the Republic of Azerbaijan; [accessed on 2020 May 19]. https://eurogeographics.org/member/real-estate-cadastre-address-registry-service-state-committee-property-issues-republic-azerbaijan/

FIG. 2020. Digital land cadastre information system in Azerbaijan; [accessed 2020 June 8]. https://fig.net/resources/proceedings/fig_proceedings/fig2020/papers/ts04h/TS04H_jafarov_khanalibayli_

GeoBuiz. 2019 GeoBuiz 2019 Report; [accessed 2020 May 19]. https://geobuiz.com/geobuiz-report-2019/

Giardino M, Perotti L, Lanfranco M, Perrone G. 2012. GIS and geomatics for disaster management and emergency relief: a proactive response to natural hazards. Applied Geomatics. 4(1):33-46.

Grafakos S, Viero G, Reckien D, Trigg K, Viguie V, Sudmant A, Graves C, Foley A, Heidrich O, Mirailles JM, et al. 2020. Integration of mitigation and adaptation in urban climate change action plans in Europe: A systematic assessment. Renew Sustain Energy Rev. 121(November 2019):109623. doi:10.1016/j.rser.2019.109623.

Harris NL, Goldman E, Gabris C, Nordling J, Minnemeyer S, Ansari S, Lippmann M, Bennett L, Raad M, Hansen M, et al. 2017. Using spatial statistics to identify emerging hot spots of forest loss. Environ Res Lett. 12(2). doi:10.1088/1748-9326/aa5a2f.

Hyunil Y, Handon J. 2012. An approach to effective land registration based on the satellite photogrammetry: Case study in Baharly, Ahal Velayat, Turkmenistan. Innovative technology in land administration.

Imamkulov U. 2019. Progress and challenges on geospatial data management for land management: [accessed on 2020 April 5]. https://www.unescap.org/sites/default/files/5.%20Progress%20and%20Challenges%20on%20Geospatial%20Data%20Management%20for%20Land%20Management_Uzbekistan.pdf

ISSA. 2020. Introduction of Institue of Soil Science and Agro Chemistry of ANAS; [accessed on 2020 April 5]. http://www.issa.az/index/torpaqlarin-genezisi-cografiyasi-v%C9%99-kartoqrafiyasi-laboratoriyasi/

JICA. 2006. The study on integrated developmnet plan of Issyk-Kul zone in the Kyrgyz Republic; [accessed on 2020 June 11]. https://openjicareport.jica.go.jp/pdf/11822020_02.pdf

JSC. 2018. Electric atlas climate user's guide; [accessed on 2020 June 8]. http://en.climate.gzi.kz/

Jung HC, Kang DH, Kim E, Getirana A, Yoon Y, Kumar S, Peters-lidard CD, Hwang EH. 2020. Towards a soil

moisture drought monitoring system for South Korea. J Hydrol. 589(May):125176. doi:10.1016/j.jhydrol.2020.125176.

Kang KH, Kim CJ, Sohn HG, Lee WH. 2010. Accuracy evaluation of ASTER DEM, SRTM DEM using digital topographic map. J Korean Soc Surv Geod Photogramm Cartogr. 28(1):169–178.

Karypov A. 2015. Cadastre and land administration perspectives in the Kyrgyz Republic; [accessed on 2020 June 11]. https://unstats.un.org/unsd/geoinfo/RCC/docs/rccap20/[LandmanagementWS]8._Azamat_Karypov_Cada....pdf

Kent AJ, Hopfstock A. 2018. Topographic Mapping: Past, Present and Future. Cartogr J. 55(4):305–308. doi:10.1080/00087041.2018.1576973.

La Notte A, Vallecillo S, Marques A, Maes J. 2019. Beyond the economic boundaries to account for ecosystem services. Ecosyst Serv. 35(November 2017):116–129. doi:10.1016/j.ecoser.2018.12.007.

Lee SH. 2018. A study on the national geographic information system of Uzbekistan. Korean Cadastre Inf Assoc. 12(3):39–57.

Lioubimtseva E, Henebry GM. 2009. Climate and environmental change in arid Central Asia: Impacts, vulnerability, and adaptations. J Arid Environ. 73(11):963–977. doi:10.1016/j.jaridenv.2009.04.022.

LPP. 2005. History of the LPP Kazkh U.U.Uspanov resarch institute of soil science and agricultural chemistry; [accessed on 2020 June 5]. http://soil.kz/en/

Maguire DJ, Longley PA. 2005. The emergence of geoportals and their role in spatial data infrastructures. Comput Environ Urban Syst. 29(1 SPEC.ISS.):3–14. doi:10.1016/j.compenvurbsys.2004.05.012.

Makhsudov B. 2015. NGIS for land management system in Uzbekistan; [accessed on 2020 June 15]. https://unstats.un.org/unsd/geoinfo/RCC/docs/rccap20/[LandmanagementWS]10._Bobomurod_Makhsudo....pdf

MENR. 2019. Azerbaijan sixth national report; [accessed on 2020 March 8]. https://www.cbd.int/doc/nr/nr-06/az-nr-06-en.pdf

Myrzagaliev. 2019. Space monitoring of the rational use of land resources of the Republic of Kazakhstan; [accessed on 2020 June 15]. https://www.unescap.org/sites/default/files/10.%20Space%20Monitoring%20of%20Rational%20Use%20of%20Land%20Resources%20of%20Kazakhstan.pdf

Nikolina Mijić S, Šestić M. 2018. Future development of NSDI based on the European INSPIRE Directive-A case study of a Bosnian and Herzegovinian geoportal. Int J Spat Data Infrastructures Res. 13:315–338. doi:10.2902/1725-0463.2018.13.art19.

Novak K. 1992. Rectification of digital imagery. Photogrammetric engineering and remote sensing, 58, 339-339.

NWRMP. 2017. National water resources management project-1: thematic maps; [accessed on 2020 March 9]. https://nwrmp.water.gov.kg/en/?page_id=1165&lang=en_GB

Park E, Song C, Ham B, Kim J, Lee J, Choi S-E, Lee W-K. 2018. Comparison of Sampling and Wall-to-Wall Methodologies for Reporting the GHG Inventory of the LULUCF Sector in Korea. J Clim Chang Res. 9(4):385–398. doi:10.15531/ksccr.2018.9.4.385.

PPRD East 2. 2016. Country profile Azerbaijan.

Qiu T, Song C, Clark JS, Seyednasrollah B, Rathnayaka N, Li J. 2020. Understanding the continuous phenological development at daily time step with a Bayesian hierarchical space-time model: impacts of climate change and extreme weather events. Remote Sens Environ. 247(November 2019):111956. doi:10.1016/j.rse.2020.111956.

Safarov NM. 2004. Features of Eological Zonation of Tajikistan. The Issues of Preservation and Rational Use of Flora of Tajikistan. Conference Materials, Dushanbe.

Scott G, Rajabifard A. 2017. Sustainable development and geospatial information: a strategic framework for integrating a global policy agenda into national geospatial capabilities. Geo-Spatial Inf Sci. 20(2):59–76. doi:10.1080/10095020.2017.1325594.

SCPI. 2019. Development of national spatial data infrastructure in the Republic of Azerbaijan;[accessed on 2020 April 5]. https://rgz.gov.rs/content/Vesti/2019/09%20-%20Septemba

r/Prezentacije/03/05%20Huseyn%20Hasanov.pdf

Shokparova D. 2019. Geospatial data analysis to design adaptive landscape system of agriculture; [accessed on 2020 March 21]. https://www.unescap.org/sites/default/files/22.%20Geospatial%20Data%20Analysis%20to%20Design%20Adaptive%20Landscape%20System%20of%20Agriculture.pdf

Tonchovska R, Stanley V, De Martino S. 2012. Spatial Data Infrastructure and INSPIRE. Knowl Br. 55:1. http://www.zillow.com/%0Ahttps://openknowledge.worldbank.org/bitstream/handle/10986/17082/762080BRI0Box30OWLEDGE0NOTES0SERIES.pdf?sequence=1&isAllowed=y%0Ahttps://openknowledge.worldbank.org/handle/10986/17082.

Tuleubayeva A. 2019. Current state of the utilization of geospatial tools in land accounting in Kazakhstan; [accessed on April 5]. https://www.unescap.org/sites/default/files/7.%20Current%20State%20of%20Utilization%20of%20Geospatial%20Tools%20in%20Land%20Accounting%20in%20Kazakhstan.pdf

UNDP. 2013. Sixth DIPECHO action plan: enhancing disaster risk reduction capacities in Central Asia.

UNECE. 2011. Country profiles on the housing sector: Tajikistan.

UNECE. 2012. Environmental performance reviews: Turkmenistan.

UNECE. 2020. National Spatial Data Infrastructure: Towards a Digital Society Conference; [accessed on 2020 June 15]. https://www.unece.org/index.php?id=52709

UNFCCC. 2020. REDD+ Web Platform, United Nations Framework Convention on Climate Change; [accessed on 2020 June 20]. https://redd.unfccc.int/fact-sheets/unfccc-negotiations.html

UZGIP. 2009. Sustainable and management information system(SLM-IS); [accessed on 2020 April 3]. https://uzgip.uz/en/projects/8/

Vardon M, May S, Keith H, Burnett P, Lindenmayer D. 2019. Accounting for ecosystem services – Lessons from Australia for its application and use in Oceania to achieve sustainable development. Ecosyst Serv. 39(July):100986. doi:10.1016/j.ecoser.2019.100986.

Williamson I, Enemark S. 1996. Understanding cadastral maps. Aust Surv. 41(1):38–52. doi:10.1080/00050336.1996.10558593.

WOCAT. 2018. Decision support for mainstreaming and scaling out sustainable land management (DS-SLM) ; [accessed on 2020 April 3]. https://www.wocat.net/en/projects-and-countries/projects/ds-slm/countries/uzbekistan#module-2

Yeon S, Kang J, Lee I. 2018. A study on real-time flood monitoring system based on sensors using flood damage insurance map. Int Arch Photogramm Remote Sens Spat Inf Sci - ISPRS Arch. 42(3W4):569–571. doi:10.5194/isprs-archives-XLII-3-W4-569-2018.

Yu Y, Chen X, Disse M, Cyffka B, Lei J, Zhang H, Brieden A, Welp M, Abuduwaili J, Li Y, et al. 2020. Climate change in Central Asia: Sino-German cooperative research findings. Sci Bull. 65(9):689–692. doi:10.1016/j.scib.2020.02.008.