

Overview of Ethiopian space program; policy priority, gaps between motivations and capabilities

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Abstract- Over the past 50 years, the use of space technology has become affordable, meaning that more countries can afford to take social and economic advantage of space technology. Ethiopia's ideal desire to develop space programs and use space technology for the well-being of society dates back to the 1950s. However, due to different reasons including weak infrastructure and facility, poverty, corruption, shortage of educated manpower, low governmental attention, and other related matter, Ethiopia's space program is not matured enough. But currently, the government is striving to advance space science and technology programs in the region for the well-being of the people across the country. As the matter of fact, the government of the Federal Democratic Republic of Ethiopia (FDRE) and the council of minister approved the establishment of Ethiopian space science and technology institute on October 2016 for making Ethiopia effective and extensive user of space science and technology applications in all aspects of developments of the country. Since then, many endeavors were made and on the 20th of December, 2019, the country marked a new milestone by launching the first-ever satellite called Ethiopian Remote Sensing satellite (ETRSS-1) in collaboration with China. It is currently little or no substantial work on space technologies and policy/strategic benefits in Ethiopia, so this article has the prospect of filling an important gap in the study area. In General, this study discusses an overview of the Ethiopian space program, achievements, and the socio-economic benefits of space technology for Ethiopia.

Index Terms-Benefits of space technology, ESSTI, ETRSS-1, satellite, space program, space technology

1 INTRODUCTION

The introduction of any new technology inevitably leads to a number of benefits and thus, space technology has provided such benefits in fair abundance, and in a number of fields. Space technology is the technology developed by space science or aerospace industry for use in spaceflight, satellites, or space exploration and it includes spacecraft, satellites, space stations, and support infrastructure, equipment's and procedures. Over the past 40 years, the use of space technology has become affordable, meaning that more countries can afford to take social and economic advantage of space technology [1]. For instance, the fast and sustainable economic growth of many developed country has been highly assisted by space technology and most of them are now well informed about the invaluable benefits, direct and indirect, derivable for the development and application of space technology [1].

The benefits of space technology are embedded in virtually all sectors, and range from the universally recognized navigation, meteorological forecasting, and broadcast of live television and internet connectivity to lesser-known applications such as in precision agriculture, transport tracking, resource extraction and monitoring of utility networks, especially which is used in planning and decision making processes^[5]. Additional applications exist in the realm of disaster monitoring and relief, insurance and military applications. Thus, data coming from satellites is engrafted in almost all economic sectors for making the world a better and safer place.

Furthermore, in most advanced economies space technology is seen as an enabler that improves lives and helps to develop both economic and social spheres.

Ethiopia's to develop space program and use space technology for the well-being of the society dates back to the 1950s [2]. However, due to different reasons including weak infrastructure and facility, poverty, corruption, shortage of educated manpower, low governmental attention, and other related matter, Ethiopia's space program is not matured enough. But currently, the government is striving to advance space science and technology program in the region for the well-being of the people across the country. As the matter of fact, the government of Federal Democratic Republic of Ethiopia (FDRE) and the council of minister approved the establishment of Ethiopian space science and technology institute on October 2016 for making Ethiopia effective and extensive user of space science and technology applications in all aspects of developments of the country. Since then, many endeavors were made and on the 20th of December, 2019, the country marked a new milestone by launching the first ever satellite called Ethiopian Remote Sensing satellite (ETRSS-1) in collaboration with china [3].

This study focuses on the overview of Ethiopian space programme; the institutional challenges, level of policy priority and the gaps between motivations and capabilities of the country.

2 PURPOSE OF THE STUDY

The aim this study is to discuss an overview Ethiopian space program and institutional challenges of the country and the level of policy priority in the sector. Besides, the study will highlight the gap between motivation and capabilities of the country in the sector and recommendation on how space technology tackle the socio-economic challenges of the country. The specific objective of the paper is to:

- (i) Discuss an overview Ethiopian space program institutional framework, goals and strategies that is mandated to bring the benefits of space to Ethiopia.
- (ii) Discuss the level of policy priority and institutional challenges.
- (iii) Discuss the gap between the motivation and capabilities and some of the recommendations with justification

2.1 OVERVIEW OF ETHIOPIAN SPACE PROGRAM

The Ethiopian space program trace back to 1950s. The first optical telescope (4-inch-wide) and geomagnetic observatory were built in 1957 by the Addis Ababa University (AAU); the aim was to enhance education and research in astronomy and space science. In 2004 the Ethiopian Space Science Society (ESSS) was established, with 47 founding members. The increasing interest of various actors in space activities has resulted in the formulation of a national strategic-vision for space and is a reason for the establishment of astronomy and space science research centers at Entoto mountain (Addis Ababa) and other highlands of Ethiopia. In 2013 the center has been established, as an independent research center called Entoto Observatory and Research Center (EORC) by ESSS, 32 public universities and one private university [2]. The observatory was established as a multi-purpose facility to support teaching, research training, and science research in astronomy and space science and for public outreach. Since then, the government turn around and express the needs to develop and build a satellite for the purposes of national security, disaster management and response, and land management. October 14, 2016 the Ethiopian space science and technology institute was established by council of minister's regulation number 393/2016. Ethiopian space science and technology institute is established under the ministry of science and technology (MOST) the former name now called Ministry of Innovation and Technology (M inT). The space council will have power and duties to

provide directions and leader ship support by evaluating space science policies, plans and strategies. It also provides the necessary guidance and support for the proper and timely implementation of the space science and technology plans of ESSTI.

The main objective of establishment of the institute are to enable the country to fully exploit multidimensional uses of space science and technologies; to acquire demand based knowledge; skilled and attitudinally matured professionals in the field of aerospace science that enable the country to become internationally competitive in the sector; to develop and strengthen space science and technology development in the country; and enable the country to be robust contributor for the development of aerospace science and technology [4].

The institute shall have the following power and duties as well: Undertake research in areas of aerospace science and technology, formulate space policy and strategy consistent with present and future needs of the country and implement same upon approval by the government, prepare aerospace development plans of the country and implement same upon approval by the government, support aerospace science and related activities carried out at national level and regulate their alignment with the national development needs, design, produce and launch aerospace development activities, design strategies that ensure the fulfillment of man power with request quantity and quality of the sector in an expeditious manner and following up its implementation, establish research centers supporting capacity development of the country's space science and technology, support local manufacturing industries in order to produce various equipment to be utilize in space development service, issue permit to person's desire to engage in space activities, control their operation, register space objects and regulate in collaboration with other relevant organs overall aerospace activities and that emanate within and outside the country and operated in the country's jurisdiction and works in cooperation with other concerned organs on space flight and activities that are related with the country's peace and security.

Institutional Arrangements

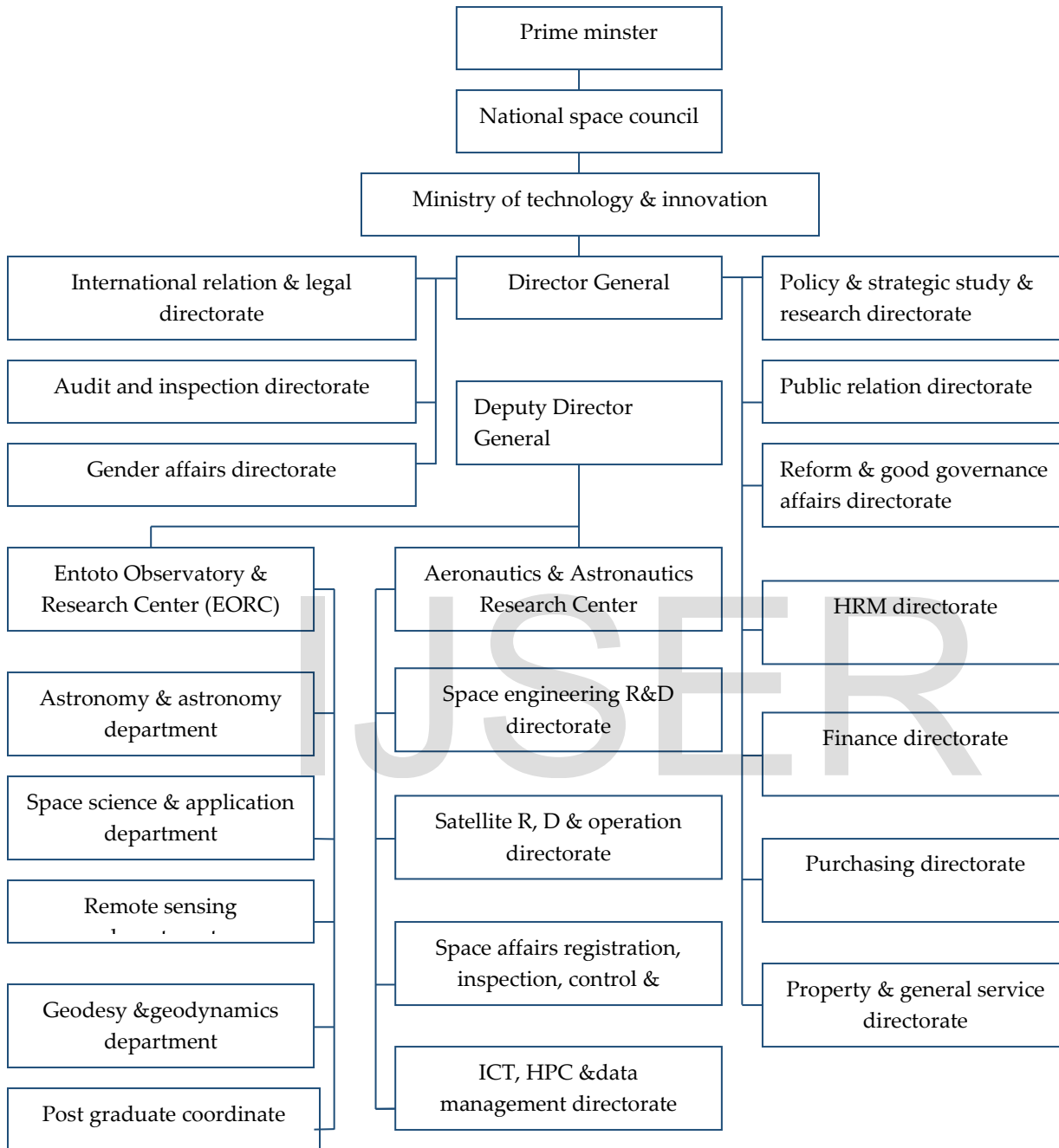


Figure 1 Ethiopian Space Science and Technology Institute structure

2.2 POLICY PRIORITY AND INSTITUTIONAL CHALLENGES

Today, many developed and developing nations, including Ethiopia, recognize the development of a national space program as an important strategic choice for achieving national development agendas and improving the well-being of humankind. Ethiopia has joined the leagues of African nations with space policies after the nations cabinet of ministers enacts the Ethiopian space policy on December 22, 2018. The national space policy is aimed to support the continued growth in the country and prepare a structure to supervise space affairs while safeguarding national security and sovereignty [5].

The policy was designed by the Ethiopian space science and technology institute, with combined structures and will be implemented in three phases.

The first phase, which is considered to be the bases for space policy, incorporates the building of space technology capacity, human power, space infrastructure and supervising space related issues. Integrating the study of space science with national development strategies to facilitate the country's economic, social; infrastructure development is the second stage, in addition to conserving natural resources, climate change and natural disaster prevention. Using for commercial purpose is also incorporated in this stage. The final stage will focus on supporting the domestic space industry and innovation required to bring to market commercial technologies. The government looks to continue partnerships with international partner to pool data for mutual benefit and obtaining service and technologies that would otherwise be unavailable [5].

There is a major national developmental challenge in general and space program institutional challenges in particular. Lack of awareness on space technology and applications, lack of scientific and technical skills, poor coordination (national and regional), low investment and financial resource in the sector and other related issues are some of the institutional challenges of the country.

2.3 THE MOTIVATIONS, CAPABILITIES AND THE RECOMMENDATIONS

Understanding of socio-economic challenges of Ethiopia and benefits of space technology very crucial to discuss the gap between motivations and capabilities of the country in

order to advance space program and tackle the socio-economic problems of the country.

Ethiopia is considered one of the oldest nations in the world but at present, the country is somehow endeavoring to transform its socio-economic conditions. Health care, food security, peace and security, skilled manpower, lack of facilities and infrastructure are some the challenges which needs attentions from all concerning individuals and groups, governments and non-governments. Space technologies can help the country to address the socio-economic challenges of Ethiopia when utilized effectively in all aspects of development. Some of the motivations, challenges in Ethiopia and how space technology can tackle these challenges will be explained in the following subsections.

- EDUCATION

Access to education increases economic prospects, broadens opportunities for social mobility, and contributes to the empowerment of women and youths. However, remote and rural communities of Ethiopia have traditionally struggled with access to education. Inadequate number of qualified teachers at all levels, absence of required text books, low quality of education, higher student teacher ratio, and demand for child labor both in rural and urban areas affect for children's access to school and drop out are the major problems of the education sector in Ethiopia [6]. Space technologies, such as satellite communications technologies, are helping to bridge this access gap and address the socio-economic issues in the education sector. For example, technologies like web and videoconferencing and voice over Internet protocol allow educators and students to create virtual classrooms, regardless of physical locations is achieved by space technologies. Other versions of distance learning like tele-education also allow learners to access web-based course materials on their own schedules, and communication between students and teachers may take place through e-mails, message boards or video recordings.

- AGRICULTURE

In Ethiopia, agriculture is the main source of income and is a critical to the success of Ethiopia's agricultural development led industrialization strategy. However, agriculture is dependent on soil and land quality, which are highly degraded. In fact, land degradation, soil erosion, drought, weather extremes and climate change along with other related environmental issues can represent costly challenges to both farmers and the overall food security of the populations [7, 8, 18]. Space technology is of value to farmers, agronomists, food manufacturers and agricultural

policy makers who wish to simultaneously enhance production and profitability. For instance, remote sensing satellite provide key data for monitoring soil, rainfall assessments from satellites, for example, help farmers plan the timing and amount of irrigation they will need for their crops, snow cover, and drought and crop development and also used for optimized agriculture and livestock management. Satellite communication and navigation are used for more efficient crop markets through better telecommunications, better emergency responses, and better delivery systems. Accurate information and analysis can also help predict a region's agricultural output well in advance and can be critical in anticipating and mitigating the effects of food shortages and famines.

- HEALTHCARE

The health challenges can transcend both national borders and traditional approaches to medical science. The low education levels, poor access to health services, insufficient access to clean water, and insufficient healthcare facilities are the main causes of Ethiopia's poor health conditions. The shortage of health care professionals is also a major problem in Ethiopia, which causes doctors and nurses to be overworked and to become exhausted, ultimately creating more problems [9, 17]. Health care providers become unsympathetic, unethical, mismanaged, and disinterested when overwhelmed. However, in recent years, space technologies have played a growing role in furthering global health objectives. Computer and telecommunications technologies, including satellite communications also enable the sharing of health and medical expertise. By bringing medical specialists into virtual contact with patients and health practitioners in remote, rural and underserved areas, tele-health and telemedicine can improve access to medical and health-related services.

- HUMAN SETTLEMENTS

Globally, more people now live in urban than in rural areas. Urban populations are also expected to grow, but the recent Ethiopian urbanization illustrates unbalanced distribution of urban population. Industrial activities and infrastructural facilities are concentrated in the capital city, Addis Ababa, Ethiopia with increasing and sometimes rapid urbanization, the cities frequently face challenges with housing, water, sanitation, electricity, crime, pollution and transportation. Space technologies provide unique tools for planning socially and environmentally sustainable human settlements. For instance, Earth Observation data for pollution monitoring, energy management and land use planning, satellite/navigation for traffic management, telecoms for efficient information exchange in the urban is

achieved by space technologies. The Central government policy makers, mayors, city planners, engineers and landscape architects are among those who use remote sensing space tools that measure and monitor existing patterns of land use and infrastructure development. Not only does this, the data inform decision makers about current urban projects, complex models can also be constructed to predict future trends in human settlements and urbanization.

- DISASTER MANAGEMENT.

Ethiopia is amongst the developing countries most vulnerable to natural and man-made disasters. Among others, drought induced famine, flood, landslide, crop-pests, wildfires, infrequent earthquake and civil wars are the major triggering events that, over the past many years, have been causing suffering to communities and millions of dollar worth of property destructions in Ethiopia [8]. A disaster cause human, material, economic and environmental losses that exceed a community's ability to cope using its own resources. Thus, disaster management aims to lessen the impacts of disasters, minimizing losses of life and property. Space technologies can contribute to all phases of disaster management cycle, including prevention, preparedness, early warning, response and construction. For example, satellite is reliable and rapid communication, observation and positioning tools, which become particularly vital to relief and recovery operations when ground based infrastructure is damaged. Before a disaster takes place, remotely sensed data provide information for systems and models, which can predict disasters and provide early warning.

- ENVIRONMENTAL DEGRADATION

Many regions in Ethiopia are affected by deforestation and a high degree of desertification. Greenhouse effect, warming (rising of atmospheric temperature), loss of biodiversity, air, water and soil pollution, soil degradation, reduction of surface water and fresh water problem, an increase number of crop failures, wind and ice damage to crops, erosion, industrial pollution, hazardous chemicals and pesticides, coastal and marine pollution and general climate change etc. are major environmental problems of Ethiopia like most African countries. Space technologies, such as remotely sensed data, have enhanced scientific understanding of water cycles, air quality, forests and other aspects of the natural environment. These surveying and monitoring tools provide valuable information on the state of ecosystems, which offers objective support for positive environmental action, including conservation and sustainable resource management.

2.3.1 CAPABILITIES

The Sustainable Development Goals express global ambitions and exhort all possible contributors of whatever stripe to assist in meeting its challenges. Given the important role already played by the space domain in development efforts and the great opportunity for increasing its contribution, space actors are called upon to seize the momentum of the SDGs to focus not only on how they can further contribute, but also on how they can become a more integral part of the community dealing with development in the greater societal context and thereby optimize effectiveness and contribution [10]. As a result, Ethiopian Space Science and Technology (ESSTI) is one of the space actors contributing on the economic development, social development and environmental protection from the three pillars of sustainable development of the region.

In order to harvest all the benefits of space technology for sustainable development 'soloed' approaches must be avoided, thus allowing to embed space even more in integrated approaches where the only measure is the adoption of the solutions that serve sustainable development best in the short as well as the long term. For instance, Ethiopia launched an earth observation satellite which is used from space is a cost-effective way of obtaining unbiased and essential data on the physical world. Decision makers use this information to understand trends, evaluate needs, and create sustainable development policies and programs in the best interest of all populations. The relevance of space science and technology for Ethiopia led by agricultural and industrial economy is utilizing space technology and pursue research to expand the economy, improve agriculture, fight climate change, disaster risk management, and create jobs.

In general, the Ethiopia's capability in the space sector is moving forward after the launch of ETRSS-1 to tackle the socio-economic challenges of the community. The importance of having national space program, is thus that they formulate a new approach to development, which has the potential to be more circumspect, but also more comprehensive in its actions.

2.3.2 RECOMMENDATION

The task of effectively using space technology in general, is a key to attain sustainable economic growth and provide excellent service delivery to the wider community. Aside the foundation, privileges, mission and goals of the Ethiopian space program, for the ESSTI to able to respond to socio economic challenges of the community and be global space actors for SDG, particular recommendations

are forwarded below regarding the need for integrated space technology development in enhancing sustainable economic growth in Ethiopia. The recommendations and its justifications are:

- ❖ **Education** (specialized or public, Human capacity building, space awareness),
- ❖ **Economics** (Infrastructure and facility expansion, strengthening space startup and Technology transfer and adaptation, Industrial development and participation),
- ❖ **Policy and law,**
- ❖ **International cooperation's**

- i) **Education** (specialized or public, human capacity building, space awareness)

For Ethiopia to address an existing challenges in the sector, there is a need for creating public awareness through regular activities, current affairs in the media, training of journalists and media men, public lectures relating to the socio economic benefits that space technology and its manifold application products and service it can deliver. Therefore, awareness and advocacy program will be vital to the development of short-term sustainable program and long term as well. Also, the appropriate expertise and skills necessary for Ethiopian space program will be area that will receive priority attention, as without this existing and envisaged the programs and infrastructure will be of limited value. In order to realize this, the general population should be knowledgeable to accept and appreciate space science and technology as a useful tool for development.

How to educate and empower human capital?

- Promote gender parity in space science and technology.
- Encourage science and technology clubs at all levels.
- Develop of curriculum and teaching aids towards space science and technology at all level of education.
- Providing an enabling environment for: Attracting the best minds towards space technology at national level.
- Engaging scientists and engineers in the Diaspora.
- Develop basic space science and technology course for non-science students.
- Builds funding mechanisms for research.

ii) Economics (Infrastructure and facilities expansion)

Appropriate infrastructure is the corner stone of an effective space technology program, enabling technology transfer and human capacity development initiatives. Initial investment in space technology is considered strategic and might prove difficult to attract private sector investment. Leverage on existing facilities in Ethiopia as well as public and private sector partnership to help build infrastructure in Ethiopia. The private-public partnerships, partnerships with some external space agencies to help build infrastructure for manufacturing of space hardware and software.

Development of the regional space industry to participate in the various functional platforms is a key requirement for the sustainability of a formal space program in Ethiopia. Space industry will be ultimate goal for Ethiopia to start harvesting the resources of space both for their use in space and to increase the wealth and prosperity of Ethiopian community. This will develop a coherent and sustainable indigenous space industry that creates a competitive and reputable global market. In addition, there is a need to ensure the long-term sustainable use of outer space environment through appropriate legislation and knowledge sharing.

How economy and investment?

- Build and strengthen Ethiopia to enable it to support space center across the region.
- Build center of excellence across the regions, expand, and upgrade existing ones.
- Build satellite assembly, integration and testing (AIT) in the region.
- Build data banks and high-performance computing centers and/or use existing ones.
- Leverage on partnerships to build space-based industry for manufacturing hardware and software and could serve as center of hands-on training.
- Develop and expand, strengthen research and development centers so that they are accessible by researchers across the entire continent.
- Expanding existing observing infrastructure and ensure data accessibility for research.
- Design and manufacture of ground segment (launching, control and receiving station).

iii) Cooperation's and partnerships

Strategic partnerships with foreign and domestic partners are necessary for tangible and intangible technology transfer and available sustainable space program that is underpinned by mutual benefits. The development of Ethiopian space program strategy should take advantage

from strong and diversified cooperation and partnership network established through a clearly shared understanding of relevant international treaties and best uses and practice. The key success factor is the creation of the linkage between international, national space sectors and other sectors such as telecommunication, agriculture, energy, Ethiopian airlines, Finfinnee Aerospace robotics and International school (FARIS), African Aeronautics and Astronautics (AAAC), security, peace and... etc.

How partnerships?

- Promote a cooperation and partnership specific framework and networking process for the development of intercontinental complementarity in the fields of human resource development, space infrastructure development, space industry development and space research and development.
- Establish cooperation agreements with governmental, intergovernmental, and regional organizations and agencies in charge of space activities. Such agreements should focus on exchange of experience and launching common programs with the objective of reducing space divide and technological gaps in terms of space access and space research and development.
- Encourage Ethiopian academia to establish partnership arrangement with academic networks concerned by space activities and join such networks
- Establish such a framework for the development of Ethiopian space industry operating in close cooperation with the foreign space industry with the purpose of establishing a complementarity between them.
- Making appropriate efforts in order to integrate the Ethiopian space infrastructure and programs as part of global space infrastructure with a clear recognition of Ethiopian rights in this regard.
- Strengthen industry-research and development partnership
- Strengthen public-private partnerships.

iv) Strengthening the policy, strategies and law

For Ethiopian space program to be fast growing and competitive sector in the region there is a need of technology policy and law for technology transfer. Technology transfer is the process of sharing skills, knowledge, technologies, methods of manufacturing, samples of manufacturing and facilities among governments and other institutions to ensure that scientific and technological developments are accessible to a wider range of users who can then

further develop exploit the technology into new products, processes, applications, materials or services [13, 16]. It is closely related to (and may arguably be considered a subset of) knowledge transfer. In globalization world market economy, driven by technology, including the Information Communication Technologies (ICTs), the transfer, commercialization, innovation, adoption and integration of technology have become more compelling. Countries that neglect these development strategies are simply lagging behind others. For example, the fast-grown countries experiences show that successful economic and social development came from having both an export-based market economy and accumulation of technological capabilities.

Ethiopia space technology transfer implementation of innovation policy targets at establishing a clear and effective STI and technology transfer, governance structure, building technological capacity in learning, adapting, and utilizing effective foreign technologies, as well as producing well-trained technicians, engineers and scientists. As one of the critical policies and strategy issue, technology transfer activities currently carried out in the country are not in line with the envisaged technology demands of the development programs and the level of qualified manpower capable of transferring foreign technology is low, and inadequate to facilitate the effective transfer of technology. Moreover, manufacturing and service providing institutions, whose involvement ranges from conducting and supporting research and technology transfer activities to contributing and implementing the policy framework, have no clear value-adding linkages between them and their role in advancing the science, technology and innovation. Therefore, transferring and adapting technology play a pivotal role in the fast movement of Ethiopian space program.

CONCLUSION

Nowadays, space application is an indispensable part of the modern society. Space technology render information and services that protect lives and the environment, contribute to sustainable development planning, enhance prosperity and security and stimulate industrial and economic development. For making Ethiopia effective and extensive user of space science and technology applications in all aspects of developments of the country, the institute should have to work horizontally and vertically on human capacity building, expansion of infrastructure, partnerships, industrial participation, space awareness and education to fill the gap between country's motivation and capabilities in the sector and realize the advantage of space technology

which can provide decision makers and planners valuable information for development planning, natural resource management, environment protection, hazard mapping, risk assessment, early warning, disaster relief and rehabilitation.

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