Utilizing the Achievements of Data Acquiring Solution and Cloud Service Platform for China-Africa Cooperation on Satellite Remote Sensing Application

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Abstract

This study examines the collaborative approach in China-Africa satellite remote sensing initiatives based on solutions of satellite data acquiring, sharing and application experiences. It specifically addresses the data coverage requirements and current coverage scenarios of China's natural resources land ssatellites in Africa. By establishing the China-Africa Cooperation Centers on Satellite Remote Sensing Application, adopting a multi-level distributed technology center model, and implementing cross-continental remote sensing cloud services through an internet-based cloud platform, this initiative aims to enhance the direct utilization of satellite data in Africa. Furthermore, strategic satellite observation window designs tailored to seasonal changes have increased the frequency of valid coverage over the entire African continent to at least once a year. Such advancements pave the way for real-time monitoring applications, particularly in crucial areas such as sustainable development projects and disaster response efforts. Therefore, the study also provides some useful case studies that are anchored on the Sustainable Development Goals.

1. Introduction

Satellite remote sensing technology has emerged as a leading technology worldwide, offering a diverse range of applications in fields such as ecology, resource management, emergency response, disaster mitigation, environmental conservation, agriculture, and climate studies. In particular, the rapid advancements in many developing countries, notably in Africa, have underscored the significant impact of satellite remote sensing technology. The border-less operation capabilities of satellites in orbit have facilitated extensive data sharing and collaboration among nations, paving the way for enhanced global cooperation. Leveraging China and Africa's technological strengths through international partnerships and drawing on recent progress in global cooperation on satellite data sharing, remote sensing technology can be harnessed to benefit society and improve livelihoods. Such a critical example is the efforts of the China-Africa Cooperation Center on Satellite Remote Sensing Application (CACSA) in the delivering of various satellite products to 23 African countries in Africa since 2016.

Earth Observation (EO) initiatives over the last decade plays a significant role in the African development and support various countries to monitor and report progress towards the uptake of the SDGs in space and time, while also ascertaining their efforts the continental Agenda 2063. The European Space Agency's TIGER Initiative, established in 2002 is one of such example that focused on water resource management using Earth observation technologies (Fernandez-Prieto D., & Palazzo F. 2007, Sarti F., Castro Gómez A., & Stewart C. 2020). This program supported both research and practical applications in addressing Africa's water-related challenges especially in the water governance in various countries in Africa. The SERVIR Programme, a strategic collaboration between NASA and USAID, offers a broader range of satellite-based data and scientific applications with the emphasis of space to the village programme. It aids developing countries not only in Africa in areas such as food security, water resource management, land use monitoring, and disaster preparedness (Mensah F. et al. 2024). The European Union's Copernicus Sentinel Programme, while not Africa-specific, provides open access to satellite data that finds various applications across the continent (Jutz, S. & Milagro-Perez M. P. (2020). This democratic approach to Earth observation has proven valuable in multiple sectors of the economy including energy, water resources and land management.

China's Land Satellite Applications Centre (LASAC) extends its support to African nations by offering satellite data for diverse developmental needs, from agriculture to urban planning. As can be seen briefly all these international programmes broadly with the aim of fostering sustainable development however their strategic approaches differ. TIGER focuses on water resources, SERVIR covers a broad range of applications, Copernicus offers a general-purpose toolkit, and LASAC provides versatile applications. SERVIR and TIGER emphasize local capacity building within African institutions. In terms of data access, Copernicus leads in openness, while LASAC typically operates through bilateral agreements. Geographically, SERVIR and TIGER have established specific regional hubs in Africa, whereas Copernicus offers African wide services. These initiatives significantly contribute to international cooperation in Earth Observation and applications providing African nations with powerful tools for sustainable development, even though their focus areas vary.

This paper highlights the use cases under the CACSA initiative and provide the technical strategy and service platform on supporting the resources, data and applications for the operation.

2. Technical Methodologies and Mechanism

2.1 Data acquisition partition analysis and solutions for Africa Based on China’s natural Resources satellites

Taking into account the factors that affect the acquisition of effective satellite data, including satellite imaging pass, imaging duration, imaging ground conditions, and combining with the near polar orbit ground pass shape of China’s natural resources land satellites with the panchromatic resolution of 2 meters (e.g.ZY3-01/02/03, GF1-B/C/D,ZY1-02D/02E),as well the locations of China’s ground receiving stations, which were mapped to the global climate classification data(Rubel, F,2010),the global surface is divide into 9 categories and 88 regions, including receiving area, arid area, rainy area, grassland monsoon area, land monsoon area, ocean monsoon area, high cold area, polar area, and no pass zone,so as to analysis the difficulty of acquiring global data including Africa. Taking the various parameters of the equipments and capacities of the satellites into consideration, conflicts on photographing at the same north-south pass was avoided by scheduling into different annual acquisition plans, which was shown in Figure 1 and explained in Table 1.

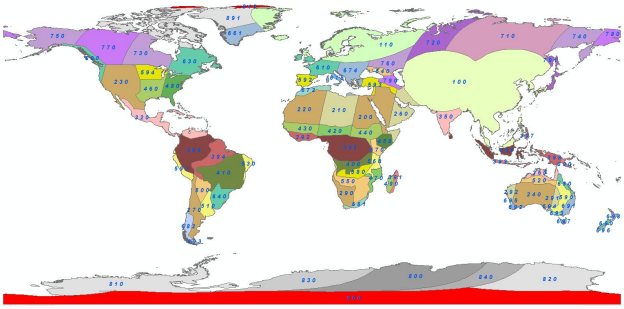

Figure 1. Global EO satellite data acquiring areas

Ground receiving area	Arid area	Rain area	Grassland monsoon area	Land monsoon area	Marine monsoon area	Cold area	Polar area	No pass area
100 110	200 210 220 230 240 260 270 290 291 292	320 350 360 390 391 392 393 394 395 396 397 398 399	400 410 420 430 440 450 460 470 480 490	500 510 520 530 540 550 560 570 580 590 591 592 593 594	600 610 630 640 661 672 674 675 680 681 682 690 691 692 693 694 695 696 697 698	710 720 730 740 750 760 770 780 790 791	800 810 820 830 840 891 893	900 910
2	10	13	10	14	20	10	7	2

Table 1. Classification partition list of global data acquiring

From the analysis of difficulty of the global data acquiring, key problems are concentrated on photographing resources conflicts, overexposure of deserts, perennial snow cover, seasonal changes in polar day and night, rainforest areas, overexposure of polar regions, and satellite inability to pass by. Fully considering the current situation of in-orbit satellites, satellite operation, satellite planning, satellite data processing technologies, solutions were provided facing the global data acquisition difficulties and the difficulty characteristics of data acquisition partitions, combined with seasonal changes, the satellite photo paragraphing priorities of each partition are sorted monthly to scientifically concentrate the difficulties of getting valid data coverage and to achieve refined planning of the data acquisition process.The priorities planning map for Africa are shown as Figure 2 and was taken into actions during daily satellite programming .

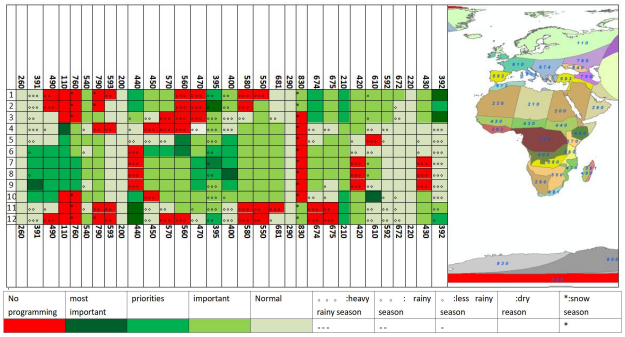

Figure 2. Classification and priority map of satellite data acquiring for Africa(and Europe)

The solutions are undertaken to practice and the valid data coverage(cloud coverage below 20%,resolution of 2-meter) of Africa from the year 2020 to 2023 as shown at below in Figure 3 and Table 2,where the coverage rate differ but all above 92%,that has served the high-resolution data sharing and application in Africa sufficiently, especially for the setting up of CACSA centers in 2023 the valid data covered 96.82% of the entire African region of 54 countries and from the darkness of the colors, some key areas were been covered multi-times with high frequency of satellite programming.

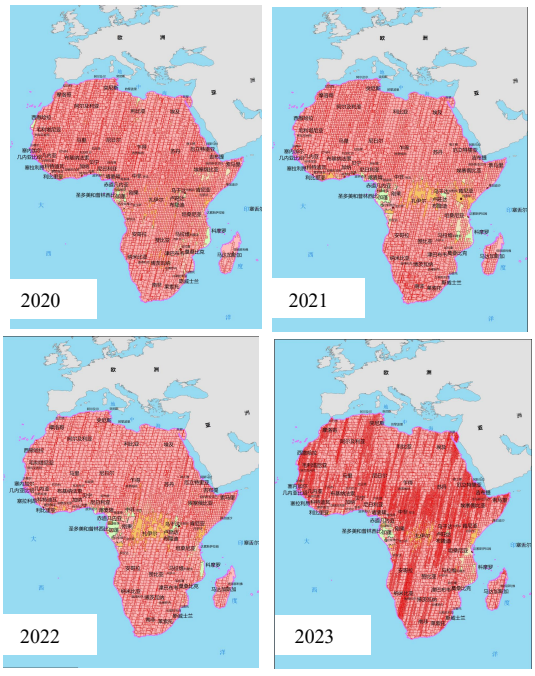

Figure 3. The valid data coverage of 8 Chinese natural resources satellites with resolution of 2 meters

Year	Coverage Area（10000km²）	Coverage Rate
2020	2830.16	94.66%
2021	2768.11	92.59%
2022	2783.75	93.11%
2023	2894.50	96.82%

Table 2. Annual Coverage of the valid data of the Africa Region

Solutions for regions hard to get the valid satellites data, such as the rainforest area, including Congo, Amazon and Southeast Asian were also proposed. First is to increase the resources of SAR satellites, second is to acquire data in advance in the poor

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rainy seasons of rainforest with the scientific strategy. The third is to improve the data selection and processing for the valid data in rainforest areas .

2.2 Cloud Service and Application

Fuelled by a spirit of innovation and committed to collaborative service delivery, the Natural Resource Satellite Remote Sensing Cloud Service Platform (SatCloud) embraces five core development principles since the year 2015. Operating with a dedication to efficiency and leveraging real-time online access to satellite remote sensing data resources, the platform caters to a global audience across diverse sectors and industries. By furnishing government entities, businesses, and the general public with a comprehensive range of classified and user-specific remote sensing data, information, and services, the platform offers multifaceted support at varying scales and levels - from macro to micro. Notably, it strives to streamline users' operational costs, reduce reliance on specialized software and hardware, and facilitate the application of satellite remote sensing for tasks spanning land cover change monitoring, natural resource surveying, as well as assessment and evaluation activities.Via this platform node in 30 foreign countries and 3 international organizations, the cloud platform have served 110 countries and territories. In particular to serve Africa more than 70,000 scenes of satellite images have been pushed to the 9 countries and 1 regional organization with the data volume more then 60TB.

The performance of the cloud service platform node in Rwanda was taken as the example in the following figure 4 as of July 2024.Since the cooperation from the January 2021, the continuous and in-time high-resolution satellite data push has achieved to 35 batches and 141 scenes .

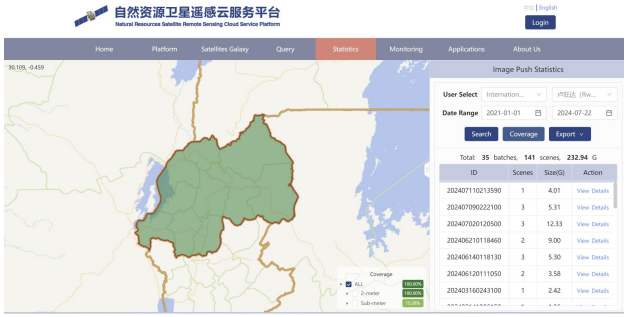

Figure 4. Data providing statistics of Rwanda via SatCloud

For Zimbabwe,as shown in Figure 5,since the cooperation initiated in July 2023 as of July 2024 the high resolution satellite images have been provided in a total data volume of 1.99TB,1018 scenes within 95 batches.

Figure 5. Data providing statistics of Zimbabwe via SatCloud

For Nigeria,as shown in Figure 6,since the cooperation initiated in May 2023 as of July 2024 the high resolution satellite images have been provided in a total data volume of 11.35TB,7115 scenes within 197 batches.

Figure 6. Data providing statistics of Nigeria via SatCloud

For Ghana, as shown in Figure 6, since the cooperation initiated in May 2018 as of July 2024 the high resolution satellite have been provided in a total data volume of 1.99TB,1326 scenes within 146 batches.

Figure7. Data providing statistics of Ghana via SatCloud

For Ethiopia as shown in Figure 6,since the cooperation initiated in May 2023 as of July 2024 the high resolution satellite images have been provided in a total data volume of 5.7TB,4154 scenes within 191 batches.

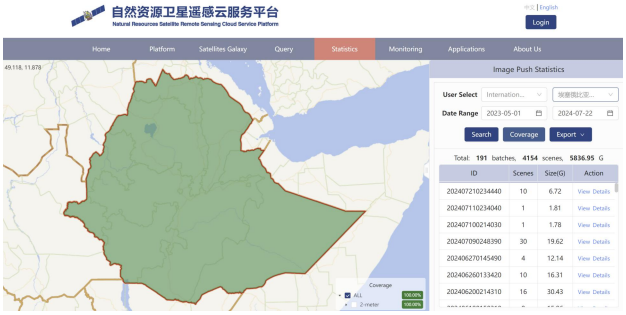

Figure8. Data providing statistics of Ethiopia via SatCloud

The above African partner countries were all covered 100% of their territories under the umbrella of CACASA benefiting from the sharing of China’s land satellite resources and data.Currently, there is an inclusion of the applications by using the above mentioned satellite data locally from Ethiopia, Zimbabwe,Nigeria,Rwanda and Ghana,such as the topographic mapping,land cover and land use mapping,disaster modelling etc .

2.3 The China-Africa Cooperation Center on Satellite Remote Sensing Application(CACSA)and its role on the SDGs

The establishment of CACSA marks a significant milestone in remote sensing filed and embodies a spirit of openness, inclusivity, and mutually beneficial cooperation.CACSA aims to enhance operational mechanisms, establish a robust data-sharing network system, facilitate data sharing, promote public goods development, demonstrate satellite remote sensing monitoring applications, facilitate personnel training, foster knowledge exchanges, and drive collaborative projects. By functioning as a nexus for knowledge sharing, experience exchange, and innovation, CACSA is poised to catalyze progress in satellite remote sensing applications for China and African nations.

The construction of CACSA is envisioned as a catalyst for advancing Africa's digital economy, bolstering poverty alleviation efforts, enhancing disaster preparedness and response, strengthening natural resource monitoring capabilities, promoting sustainable water resource management, and safeguarding environmental conservation.The establishment of international nodes for land satellite services, as previously outlined, has become imperative. This initiative stemmed from a survey conducted in FOCAC, revealing a crucial gap in satellite mission focus - particularly concerning essential mapping information crucial for the foundational resource management of developing nations. Discussions with nations in Africa, for example, underscore the diverse array of vital needs, ranging from water and sanitation access to healthcare and education, often relegating the collection of basic national infrastructure data to Surveying and National Mapping Agencies. Consequently, CACSA’s role proves instrumental in bridging this gap and extending support to developing countries in advancing their vital missions.

3. Case Studies

3.1 Rwanda

The Rwanda Space Agency (RSA) is advancing the uptake of Earth Observation technologies for the disaster management through a strategic partnership with the with Land Satellite Remote Sensing Application Center,Ministry of Natural Resources of P.R.China (LASAC,the implementation lead of CACSA at China side). This collaboration significantly enhances RSA's contribution to multiple Sustainable Development Goals (SDGs) such as SDG 13 (Climate Action) and SDG 11 (Sustainable Cities and Communities). LASAC's expertise in satellite remote sensing technology and data analysis has been instrumental in boosting RSA's capacity. This partnership exemplifies SDG 17 (Partnerships for the Goals), showcasing international cooperation in space technology. RSA's GEO-Hub, enriched by LASAC data streams allow RSA to efficiently process various imagery formats from multiple satellite sources. This improved capability of Rwanda’s early warning systems for climate-related hazards, directly supporting SDG 13. LASAC's datasets and expertise has been crucial in developing RSA's applications for mapping flood and landslide-prone areas and hence promote the support SDG 15 (Life on Land) by promoting integrated land use planning and management. LASAC and RSA partnership is playing a pivotal role in Rwanda's sustainable development journey and providing a good example for other nations in Africa in the uptake of EO for societal benefit.

3.2 Zimbabwe

The Zimbabwe National Geospatial and Space Agency(ZINGSA) through its collaboration with China's Land Satellite Applications Centre (LASAC) from January to May 2024. The data, sourced from Chinese Earth observation satellites including the Gaofen (GF) and Ziyuan (ZY) series, showed a progressive increase in sources over the months. This exemplifies global partnerships for sustainable development (SDG 17), fosters the transfer of innovation in Earth Observation Uptake, improves technological capabilities (SDG 9), and provides crucial data for monitoring climate change impacts (SDG 13). The ZSA intends to use this crucial satellite imagery to support ecosystem monitoring and biodiversity conservation (SDG 15), aid in urban planning (SDG 11), agricultural monitoring, planning and food security interventions (SDG 2), and help support integrated water resources management (SDG 6). Therefore, this partnership is providing the Zimbabwe Space Agency in gaining access to valuable Earth observation data, positioning the country to make evidence-based decisions across multiple sectors relevant to its sustainable development goals. This collaboration also highlights Zimbabwe's efforts to develop its space capabilities and applications, potentially inspiring other African nations to pursue similar partnerships in their advancement of sustainable development and the AU Agenda 2063.

3.3 Nigeria

Nigeria's National Space Research and Development Agency (NASRDA) is a key player in the space industry in the African continent, supporting her country's sustainable development efforts, leveraging space technology to address several Sustainable Development Goals (SDGs). For instance, NASRDA's achievements are among others include the launch of NigeriaSat-1 and NigeriaSat-2 satellite to boost Nigeria's technological capabilities innovation, infrastructure and application development. LASAC plays an important role in this direction by supporting NASRDA with access to advanced satellite data imagery. This collaboration enhances NASRDA's capacity to undertake various projects across several sectors, each addressing specific SDGs. agriculture, LASAC's satellite data supports initiatives like the Crop-Watch Innovative Programme, enhancing food security monitoring (SDG 2). NASRDA's partnership with LASAC exemplifies SDG 17, demonstrating the power of international collaboration in space technology. By aligning its projects with the SDGs and leveraging LASAC's resources, NASRDA aspires to play a crucial role in Nigeria's progress towards achieving these global goals and the AU Agenda 2063.

3.4 Ghana

The Ghana Space Science Technology Institute (GSSTI) has announced its intention to utilize satellite datasets provided by LASAC for crop yield prospect analysis. This initiative demonstrates Ghana's commitment to leveraging space technology for agricultural development and food security. The datasets, which include imagery from the Gaofen (GF) and Ziyuan (ZY) satellite series are being integrated to an existing Crop Intelligence Platform being developed by the institute. Hence, the datasets would have strengthened their capacity to improve algorithms for monitoring crop growth, assess vegetation health, and predict harvest outcomes across Ghana's agricultural regions. This vital for supporting the country’s

agenda on Planting for Food and Jobs Agenda of the Government and hence support SDGs 13, 15 and 1. By employing these advanced Earth observation technologies, GSSTI aims to provide timely and accurate information to farmers, policymakers, and other stakeholders in the agricultural sector.

3.5 Ethiopia

The Space Science and Geospatial Institute(SSGI) is leading the Ethiopian Space Programme and is currently utilising Earth observation technologies for sustainable development. The launch of Ethiopia's first satellite, ETRSS-1, in 2019 marked a significant milestone for the country and the continent with several contributing indicators to SDGs 2, 6, 13, and 15 such agricultural monitoring, integrated water resources management and disaster monitoring.

LASAC plays a crucial role in Ethiopia's space endeavors. This partnership exemplifies SDG 17 (Partnerships for the Goals) and significantly enhances Ethiopia's access to high-resolution satellite imagery thereby expanding Ethiopia's Earth observation capabilities. A key initiative benefiting from this collaboration is the comprehensive Land Use Land Cover (LULC) mapping project which is being implemented underway. This ambitious project aims to create a detailed 1:50,000 scale map of Ethiopia, utilizing LASAC-provided imagery and advanced analytical tools and support systems. This project provides supports to urban development (SDG 11), agricultural monitoring (SDG 2), disaster risk reduction (SDG 13), and natural resource management (SDG 15). With this partnership with LASAC, Ethiopia is positioning itself at the forefront of using Earth observation for sustainable development in Africa. This approach is not only aiming to support Ethiopia to support multiple SDGs but also set an example for how developing nations can use space technologies to address pressing developmental and environmental concerns with rapid population growth.

4. Conclusion

The inception of CASCA for Africa marks a significant stride in advancing the AU Agenda 2063 and driving economic growth within the region. These CACSA initiatives, facilitated by the MNR, play a pivotal role in aligning with these key agendas, utilizing a diverse spectrum of satellite applications in conjunction with the Group on Earth Observation Post 2025 Strategy. This strategic alignment aims to provide African nations access to high-resolution datasets essential for fostering sustainable economic development. The CACSA model's scalability offers promise for broader implementation, extending to regions like the Pacific Islands and beyond, signaling a commitment to global accessibility and impact.

5. Future Work and Recommendations

The China-Africa Cooperation Center on Satellite Remote Sensing Application is the ongoing mechanism to support African countries with the products and services being provided by LASAC, aims to enhance African countries' access to satellite data and technology. To maximize its impact, several key recommendations are proposed:

1.Open Data Policy: Implement a comprehensive policy allowing free access to satellite imagery and products for African researchers, institutions, and governments. Develop user-friendly data portals and APIs for easy distribution of data.
2.Capacity Development: Establish regional training centers for hands-on training in satellite data processing and analysis. In addition, develop an online learning platform tailored to African needs and implement exchange programs with Chinese experts.
3.Tailor-made Products: Co-design and co-develop with African institutions products addressing local challenges in critical sectors such as agriculture, water management, urban planning, and disaster response while taking into account feedback mechanisms for continuous improvement and development.
4.Infrastructure Development: Support the establishment of local ground stations and data processing centers in strategic centres in Africa that support in high-performance computing facilities for big data analytics.
5.Collaborative Research: Co-design and initiate joint research projects between Chinese and African institutions while promoting publication in open-access journals to promote knowledge sharing.
6.Integration with Existing Initiatives: Explore opportunities with other international Earth observation programs to ensure complementarity of efforts while co-developing interoperability standards for easy data integration.
7.Sustainable Funding Model: Jointly develop a financial model that ensures long-term operation through Chinese support, African government contribution and international partnerships.
8.Application Development: Promote mobile application development to bring satellite-derived information to end-users especially recognising the growing need of African tech startups in developing value-added services.
9.Policy Support: through bilateral engagement promote African governments to promote the use of EO data in support of their decision-making processes and protocols to provide transparency in the governance and use of their resources.
10.Outreach and Education: Promote and implement programs to raise awareness about satellite applications while taking steps to integrate satellite technology into university curricula across relevant interested partners Universities in Africa.
These recommendations aim to position the Centre as a cornerstone for technological advancement and sustainable development in Africa while addressing issues of Sustainable Development Goals 2030 and the AU Agenda 2063. Through this the future CASAC can play a crucial role in leveraging space technology for African development.

Acknowledgements

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