The contributions of space geodesy to the construction of sustainable cities in Africa and around the world.

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Abstract The accelerate urbanisation African cities caused by the massive rural exodus contributed to the demographic boom of these cities. Our cities barely breathe. The swamps of yesterday have become the habitats of today, the marine areas become a refuge by excellence for families newly arrived in the city. This is the birth of precarious neighborhoods with growing land insecurity. The disappearance of marine and coastal biodiversity, the increase in pollution in all its forms; this is where space geodesy comes in. Recognized as one of the great revolutions of Navigation. Space geodesy has made available to territories and continents including the oceans a set of techniques that in their applications participate in the construction and management of sustainable cities in Africa and in the world; it participates through its fields of application in atmospheric monitoring, marine environment monitoring, territorial, climatological to ensure a better life on land, underground, in water and under water. These techniques and application are an urban decision support for the construction and management of sustainable cities; precise geodetic measurements make it possible to assess topography, identify flood zones, with facilitates the installation of resilient infrastructure.

1 Introduction

In Africa and specifically in Benin, the management of cities continues to be a very complex process. With nearly a quarter of a century of application, decentralization in our countries has still not been enough to have a better management of our cities, municipalities and city districts. The climate shocks of the moment coupled with the environmental challenges of the decade have pushed all decision-makers at national and international level to reinvent our cities, municipalities and city districts to put an end to the inadequacies of the management system in place while taking into account the challenges of the 21st century in the new definition and management of the city. This is how we have moved from cities to sustainable cities. There is definitely no sustainable city without good coastal management and effective land security.

In West Africa, several economic, social and legal factors are favourable to land tenure insecurity. More specifically, it can be an increase in the value of land, the cost of access to a land title; an explosion ddemographics, land disputes, ignorance of the texts and laws governing land ownership, lack of coordination between judicial bodies, slow completion of land disputes at the level of the competent courts. It is in this context where land insecurity is still relevant and where indigenous peoples continue to be dispossessed of their lands for lack of a reliable and secure management system, that our cities are bathed. Access to land ownership and securing land rights, for poor and rural populations in general and for women in particular, is essential for food and land security and therefore for the security of our cities; land tenure security is therefore a major challenge to ensure the construction of sustainable cities in Africa.

With its 26,000 kilometers of coastline and the density of its hydrographic network, Africa is the second largest continent after Asia. Here in Africa, all it takes is an overflow of waters, a rise in sea level for us to go from a city to a pond. Africa, when it is a victim of rising sea levels, finds itself faced with an avalanche of crisis whose consequences are disastrous. Here, when surface water invades us, groundwater splashes us. They transport on their way the contents of gutters, sewers, septic tanks and deposit them in breeding ponds of microbes to promote the proliferation of waterborne diseases; accelerates the erosion of coasts, roads and buildings. Thus, every year, according to the seasons,

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African cities face what can be described as a humanitarian crisis.
Space geodesy in its earth observation missions has made available techniques to not only manage and secure land and then the coastline but also provide the data and information necessary for the construction and management of its two natural resources for a sustainable city. Carried out in sub-Saharan Africa more precisely in the West African context, this study began in March 2021 during the defense of my thesis on "the impact of modern topography devices on man and his environment. Our document consists of three main parts. The objectives that represent the goal of the research methodology that traces the way in which the research was conducted and then the results that will initially show the roles of space geodesy applications and techniques in the fight against the effects of climate change; and then show how spatial geodesy techniques are used in land tenure security and coastal management.

1.1 Research objectives

Our goal is to analyse the contributions of spatial geodesy to the construction of sustainable cities.
Specifically, it is a question of:

-Present the opportunities offered by some applications of spatial geodesy in the realization and management of sustainable cities;

-Determine techniques from space geodesy;

-Show the importance of their uses in securing land.

1.2 State of the art

It is a question of shedding light on all the studies, reports and briefs that are available to us and that go almost in the same direction as our study.
Thus, the first thesis to have caught our attention is that of Raphaël GRANDIN of the Institute of Physics and the globe of Paris in the specialty "Earth, universe, environment" and whose title is "From the source of earthquakes to risk seismic: contribution of space geodesy"
With the general objective of responding to the contribution of space geodesy in the quantification of seismic risks and the source of earthquakes.
In his 206-page dissertation written in order to receive an accreditation to Supervise Research, Raphaël GRANDIN speaking of space geodesy states that “recent advances in space geodesy allow access to the finite slip distribution on fault systems during
and between major earthquakes. In particular, wide-swath radar interferometry (InSAR) notably thanks to the Sentinel-1 constellation, now provides means of observation with high revisit frequency, capable of measuring tectonic deformations at high>> [1].
Scale, with increased precision and temporal resolution ; The current HDR Lecturer, Institut de Physique du Globe de Paris (IPGP) at University of Paris (UP) in the specialty "Space geodesy and remote sensing applied to active tectonics and volcanism" Raphaël GRANDIN since it is about him affirms in his writings that "the development of methods joint inversion of space geodesy data (InSAR, optical correlation, GNSS) and seismological therefore makes it possible to build a precise representation of rupture processes, and thus to test and push the limits of the various existing seismic cycle models" [1].
The author who, joins our theme by addressing here, the contribution of space geodesy to the quantification of natural disasters such as earthquakes, earthquakes has already done part of the work [1].
Before Raphaël GRANDIN, Xing Xing Li looked at a problem that is close to that of GRANDIN in his article entitled "Real-time high-rate GNSS techniques for earthquake monitoring and early warning". [2]

L. Awange in his book Environmental Monitoring using GNSS, from page 57 to page 90 states that, the observed parameters necessary for environmental monitoring vary, depending upon the indicators being assessed. Some are physical variables such as changes in soil patterns, vegetation, rainfall, water levels, temperature, deforestation, solar and UV radiation. Others are chemical variables , e.g., pH, salinity, nutrients, metals, pesticides, while others are biological variables , e.g., species types, ecosystem health, and indicator species [3].

In order to understand the expression "sustainable cities", we have gone through more than one document including this one by Vincent Beal entitled "Sustainable city and social justice. What sustainable development tells us about urban production"
For the author, sustainability is often presented as a new urban utopia. A "feasible utopia" that could be built by all the individuals populating urban spaces.
This utopia according to V. Beal would make "it possible to reconcile economic development, harmonious relations between man and nature and social justice. However, if the sustainable city model does propose an ideal of social justice, it must be understood in the sense in which David Harvey defined this notion. In his book Social Justice and the City, he showed that social justice was by no means universal, that it depended on the spatial and temporal contexts in which it was enunciated"[4].

Above all, it showed that the debates around urban development in the city of Baltimore brought together different arguments put forward by different social groups and all hiding behind a different conception of social justice. This is probably how we should understand the ideal of the sustainable city. The author defines the sustainable city as a utopia of social justice created by and for certain social groups – the creative, the bobos, the yuppies, etc. – whose demographic weight within urban societies and, above all, the influence on the content of urban policies are constantly increasing; as a vision of social justice stripped of its classist dimension and its conflictual dimension [4].
Nevertheless, the author asserts that sustainable development policies can be a means of attracting certain social groups, this is what he clearly states when he says "However, if the discursive use of
References to an "urban nature" is much less present, sustainable development policies being reused as an urban marketing tool, particularly in the case of

rehabilitation of waterfronts or rivers, recreation of urban green spaces, uses of the prefix "eco", can also be seen as a way to attract certain social groups and to overcome the desire for life in the countryside that derived in many cases from research. an "existential security" linked to proximity to nature."

The vast majority of authors who deal with security or land management use Geographic Information Systems (GIS) as land security tools. If we are not against this truth, we nevertheless remain cautious about the way in which space geodesy is invisible and about the lack of literature dedicated to this discipline which is actually the science allowing the determination of the shape and dimensions of the Earth. The land being here considered as a portion of a territory, the primary basis for securing it remains the determination of its shape and dimensions; this is the role of geodesy and it is spatial when this shape and its dimensions are determined thanks to sources outside the Earth.

Our work therefore comes at the right time and will serve to make space geodesy and its advantages for sustainable development in general and urban development in particular more visible.

2 Methodology

Global Navigation Satellite Systems (GNSS) are revolutionizing the world in a way their original developers never envisaged. From being military “war” tools, GNSS satellites are rapidly becoming “peace” tools that play a potentially critical role in GNSS satellites are rapidly becoming tools for "peace" that play a potentially critical role in building sustainable cities [3].

The methods used for the collection of information range from documentary research on spatial applications to urban planning and geospatial science techniques and scope. Field operations were also taken into account in the collection and analysis of results. This study was carried out in two phases: an exploratory phase with topographers, surveyors, urban planners, community development agents, and planning professionals. The second phase of this study was based on existing work, projects and programmes on sustainable cities and spatial geodesy, geospatial data at BENIN, in Africa and worldwide.

The purpose of the exploratory phase required, at first glance, a simple interview of land specialists, planning specialists, urban planners and community development officier. The second phase made it possible to identify the major works carried out in cities, city districts, villages, communes, regions of Benin, Africa and the world using space geodesy techniques and applications. In view of these two phases, two priority issues for the construction of sustainable cities thanks to the contributions of spatial geodesy have been defined: land tenure security including urban planning and the management of rivers and bodies of water including the risks of natural disasters. Surveyors-topographers have been identified as key players in land tenure security.

They are upstream and downstream of all work affecting land, watercourse; So to the city and the first civilian users of GNSS receivers, we have therefore constituted two groups of samples for the survey each consisting of:

-a topographic operator, a surveyor-topographer engineer and a doctor in spatial planning and a GIS specialist.

-a senior technician Surveyor-topographer, a Surveyor-Topographer Engineer, a community agent, an Urban Planner.

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Twenty-four individual semi-structured interviews were conducted by a single person. The interviews took place from March to May 2021. This type of interview allowed us to receive a lot of important information on the problem. The twenty-four interviews were reformulated and integrated into the results. We have therefore proceeded to the exploitation of the data collected by the method of content analysis and more specifically to the thematic analysis which allows the highlighting of the social representations or judgments of the interlocutors from an examination of certain constituent elements of the discourse: knowledge of the theme, restitution, memorization and appreciation of information tools, frequency of handling GNSS receivers.

The collection of data on major work carried out or underway in Africa and the rest of the world using spatial data or other techniques and applications of space geodesy made it possible to integrate the literature review into our research.

Thus, twenty different research works related to the theme were consulted, fourteen works were exploited for effective treatment and reliable, verifiable and accurate results.

3 Results

3.1 Space geodesy in the face of the climate emergency

Known for its applications on earth, physical geodesy understood that it was necessary to leave the earth to be able to observe and characterize it. It has therefore acquired a space dimension for better observations from space thanks to spacecraft, both natural and artificial satellites. More, precisely, it is a set of several applications which, in their implementation, use or involve various techniques of geodetic sciences.

Among its applications, we have remote sensing which is in turn used in several fields of application such as: meteorology, climatology, oceanography, cartography, remote sensing of the atmosphere, terrestrial and meteorological [5].

3.2 The monitoring systems

3.2.1 Weather and climate monitoring systems

Meteorological, climatological and atmospheric monitoring systems allow us to observe and track the behaviour of cloud masses, their distributions and properties as a function of time. It is through these systems that we have weather information on earth [5].

3.2.2 Terrestrial surveillance systems

Terrestrial monitoring systems are systems that provide geographic information about the earth and the changes it undergoes.
The Copernicus Earth Monitoring Service (CLMS) provides geographic information on land cover and its changes, land use, vegetation condition, water cycle and energy variables at the Earth's surface [6].
It supports applications in a variety of fields ranging from spatial and urban planning to forest and water management, agriculture and food security, nature conservation and restoration to rural development, all of which contribute to climate change mitigation and environmental management.[6]

3.2.3 Marine Environment Monitoring System

The observations and forecasts generated by the Copernicus Marine Environment Monitoring Service (CMEMS) offer multiple applications in the maritime domain like Maritime safety; Marine resources Coastal and marine environment [6].
The availability of Copernicus Maritime Service data on the African coasts to protect during oceanchalleng4africa 2022 competition allowed our team to choose a suitable site to host a coastal wetland. The service also contributes to the protection and sustainable management of living marine resources in particular for sustainable fisheries management or the decision-making process of regional fisheries organisations. Physical and marine biogeochemical components are useful for water quality monitoring and pollution control.
Sea level rise is a key indicator that helps assess coastal erosion.

Satellite data can be used to measure ocean height, melting glaciers and ice sheets, the distribution of water masses on Earth, and tectonic plate movements. This information is essential for understanding the impacts of climate change on the Earth and for developing effective strategies to combat climate change.

3.3 Land tenure security and coastal management for Sustainable African cities.

3.3.1 The urgency of land tenure security

For the majority of people in developing countries, land tenure insecurity is a very concrete reality; L
land rights are a luxury, given that only 30% of the world's inhabitants hold formal title deeds. Securing land rights is an important issue for poverty reduction and shared prosperity at the country level [7].
Recognition of land rights is key to boosting investment and growth, particularly in agriculture and infrastructure; It also makes it possible to combat expropriations and forced migration and thus contributes to the resilience of countries and their populations to shocks [7].

"Building sustainable societies requires solving land issues: countries, regions, cities, and villages need well-established property rights, clear borders, and accessible land services to grow economically," said Ede Ijjasz-Vasquez, Senior Director of the World Bank's Social, Urban, and Rural Development Practice. "Authorities need accurate geographic information to plan for road construction, the development of public services and infrastructure, and in doing so, create jobs" [7].
But securing property rights is not only useful from a country's growth and investment climate perspective. It is also a crucial aspect of social inclusion, especially for historically marginalized social groups, including indigenous peoples, including women and youth.
Finally, securing property rights is important for families and individuals. Thus, it is essential that women are not excluded from this process, as the consequences are far-reaching in terms of household income, food security and equity.
Securing land rights is above all a key to women's empowerment and urban development [7].

In a classic way, a city is a geographical and social environment formed by an important meeting of buildings housing inhabitants who work, for the most part, within the agglomeration. The sustainable city of the 21st century can therefore bedefined as a geographical and social environment formed by a mix between constructions made of innovative materials and green spaces and which integrates indigenous peoples in its operation while promoting the sustainable conservation of their lands and where the risks of natural disasters are can be estimated over time. GPS relative kinematic positioning is usually adopted to estimate seismic displacements as double-differenced ambiguities can be fixed to integers for guaranteeing high accuracy [8].
There can be no sustainable cities without securing the territory. Before securing a thing, an object, a land, it is necessary to know precisely its location in time and space. This is where space geodesy comes in through satellite positioning systems including GNSS (Global Navigation Satellite Systems).

3.3.2 The satellite positioning system.

The satellite positioning system also known as GNSS (global navigation satellite systems) is a set of components based on a constellation of artificial satellites to provide a user via a small portable receiver with its 3D position, 3D speed and time. This category of geopositioning system is characterized by metric accuracy, its worldwide coverage and the compactness of the terminals, but also by its sensitivity to obstacles present between the receiving terminal and the satellites. Some augmentation and reliability systems of regional or global scope, free or paid, make it possible to make

the system reliable and improve performance (DGPS, EGNOS, A-GNSS, etc.)

3.3.3 Usefulness of satellite positioning systems

The surveys carried out during our research work allowed us to understand the usefulness of geodesy in urban planning. Indeed, we have detected several uses of space geodesy in favor of the construction of sustainable cities in Africa that we have grouped into five different categories. From the detection of illegal occupations to the monitoring and evaluation of land, urban planning and management policies, to mapping and management of land information, not to mention the collection of accurate data.

Thus, for the detection of illegal occupations, Satellite imagery and radar data can identify land use and unauthorized, encroaching construction, allowing authorities to take appropriate action to enforce land rights. This information is particularly valuable in areas where access to land is difficult or where illegal activities are hidden.

Concerning Catography and Land Information Management, Land mapping, which uses remote sensing techniques, provides a visual and understandable representation of land information.

High-resolution satellite imagery, with the advent of LiDAR data, provides details on physical terrain characteristics and land use.

This information, combined with geodetic data, facilitates effective land management and planning, ensuring effective protection of land rights and prevention of land-use conflicts.

For the urban planning and management policies

In an urban context marked by the phenomena of metropolisation and globalisation, new issues are emerging and generating new forms of governance.

Radar images provide information on building density, land use patterns, urban infrastructure growth and development trends. This accurate mapping is essential for urban planning, land management and sustainable development decision-making.

By allowing the detection of infrastructures, they offer a synoptic and detailed view of urban infrastructures, which makes it possible to assess their condition, identify maintenance needs and prepare the city to welcome new construction.

To monitor and evaluate land policies, satellite positioning systems using in situ observations provide valuable data for assessing the effectiveness of land policies and development programmes. By monitoring changes in land use over time, geospatial data can be used to assess the impact of land policies on sustainable developmentnatural resource conservation and poverty reduction. This information enables policy makers to make informed decisions and adjust land policies according to local needs and realities.

Satellites orbiting the earth also allow us to collect data. Here, we are talking about data collected directly in the field using GNSS receivers. GNSS receivers make it possible to accurately measure the coordinates of plots of land. Using satellite positioning techniques (GNSS), we can accurately determine property boundaries and create reliable geodetic references. This data plays an essential role in establishing clear and indisputable title deeds that ensure legal certainty of land transactions.

GNSS receivers make it possible to accurately measure the coordinates of field plots.

3.4. Coastal management

The littoral zone is defined as the part of a territory where a course or body of water is in contact with the land. The need to house the growing populations on the one hand and the presence of a vulnerable coast on the other jeopardize the fragility of the coastline.

Particularly significant challenges arise in coastal, riparian and island communities, affected by flooding and submersion, as well as accelerating coastal erosion. These impacts are exacerbated by rising sea levels, changes in winter conditions and an intensification of extreme weather events.

To overcome this state of affairs, space geodesy and remote sensing altimeter satellites measure the height of the sea surface several times to detect seasonal variations These measurements make it possible to monitor changes in sea level in real time and identify long-term trends to make navigation at sea safer, determine favorable conditions for sports and cultural activities on the coast and install a safety cordon.

By using space techniques to measure changes in sea level height, scientists can better understand the effects of global warming and melting glaciers on sea level rise. They can also study the impacts of sea level change on coastal ecosystems, human populations and coastal infrastructure.

Better coastal management makes it possible to control the behaviour of surface waters and to enable sustainable management of cities in Africa and around the world.

3.4.1 Flooding and overflowing waters

The ocean covers more than 70% of the planet. It is our source of life, Looking at the horizon, the ocean seems limitless and out of reach. The skyline marks the boundary between the terrestrial world and the maritime world; Yet, it only takes one unusual rain for it to invade us [9].

In this context where the world is becoming more and more uncertain, especially because of the climate change, it is therefore becoming necessary to develop new strategies for flood risk management to anticipate flood scenarios that models probabilists judge as extreme or rare, Water overflow scénarios.

Thus, thanks to space science and technology, we can already protect and monitor coasts, control activities along the oceans and all waterways.

3.4.2 Usefulness of satellite positioning systems

The use of space geodesy is not only terrestrial, it is also marine, coastal etc. Satellites in orbit around the earth also carry out observations at coastal level and allow us to have information on different aspects of the

coastline and rivers. These are: Management of sensitive coastal areas, coastal monitoring and mapping, coastal risk forecasting, coastal Development Planning.

Thus, for coastal monitoring and cathography,
Space geodesy provides accurate measurements of coastal morphological changes, including the evolution of beaches, dunes, and estuaries. Airborne LiDAR surveys provide detailed topographic and elevation data to map changes in coastline and quantify coastal erosion. Remote sensing, using satellite imagery and radar sensors, can also monitor sediment movements, coastal currents and changes in coastal wetlands..
For the coastal risk forecasting, the combination of geodetic data and remote sensing makes it possible to model coastal risks such as erosion, storms and marine submersion. Using accurate numerical terrain models (DTMs) and hydrodynamic simulations, it is possible to estimate high-risk areas and plan appropriate adaptation measures. Continuous remote sensing coastal monitoring also provides real-time data on extreme weather events, allowing for a quick and effective response in the event of an emergency.
The littoralization of socio-economic development is manifesting itself in an accelerated manner. It has thus generated strong competition over space and coastal resources, causing conflictual relations between sectors, particularly in terms of spatialization of activities. By mapping these ecosystems and monitoring their health, priority conservation areas can be identified and appropriate protection measures put in place.

In addition, remote sensing provides tools to assess water quality, marine biodiversity and anthropogenic pressures on coastal ecosystems, thus facilitating the integrated and sustainable management of these fragile area.
Space geodesy and remote sensing are valuable tools for sustainable coastal zone planning and management. By providing accurate data on topography, sea level, the combination of geodetic and remote sensing data provides a better understanding of the physical characteristics of the coastline, such as topography, altitude and slopes. This information is valuable for coastal development planning, identification of risk areas, demarcation of building zones, prevention of illegal land use and preservation of sensitive natural areas. They also contribute to the development of integrated coastal management plans, taking into account environmental, social and economic aspects.

4 Conclusion

Space geodesy is the basis for the acquisition of data by orbiting satellites or other spacecraft in the fight against climate change that are crucial in the construction of sustainable cities in Africa.
From controlling the hydrographic network to mastering the exact dimensions of the earth, it gives us data that we use to prepare a strategic response to the environmental challenges of the 21st century; The sciences of space geodesy are fundamental tools for the well-being of man and his environment. Today, everyone receives a signal whether through a mobile phone, a connected geodetic GNSS receiver, everyone enjoys the benefits of science and the work of these brave astronauts, engineers and geodesists. But is there an environmental and social impact study on all permanent stations installed on earth? [10] Thus, to enable Africa to take full advantage of these disciplines and one day have its satellite positioning system such as the American GPS, the Chinese Beidou, the European Galileo or the Russian Glonass, it is important to strengthen the capacities of land and urban planning actors in geo-spatialization and remote sensing techniques in developing countries, to promote international collaboration for the effective and ethical use of data from space geodesy techniques and sciences with respect for man and his environment in order to guarantee data security and the preservation of man and his environment.

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