دور نظم الأقمار الاصطناعية في إيصال المعرفة العلمية إلى مختلف أرجاء العالم ودعمها: دراسة تحليلية

The Role of Satellite Systems in Delivering and Supporting Scientific Knowledge Across the World: An Analytical Study

Prof. Dr. Fadhil AbdAli Khirmeed

University of Wasit

College of Administration and Economics

fadhilabdali@gmail.com

تاريخ الاستلام: 2026/07/06 تاريخ القبول: 2026/10/17 تاريخ النشر: 2026/11/06

المستخلص

يهدف البحث إلى تحليل دور نظم الأقمار الاصطناعية في إيصال المعرفة العلمية إلى مختلف أرجاء العالم ودعمها، ولا سيما في المناطق الريفية والصحراوية والجبلية والجزرية والمناطق التي تعاني من ضعف البنية التحتية للاتصالات. وتنبع أهمية البحث من التحول المتزايد نحو الاقتصاد الرقمي والتعليم الإلكتروني، وما يتطلبه ذلك من وسائل اتصال قادرة على تجاوز القيود الجغرافية والاقتصادية. واعتمد البحث المنهج الوصفي التحليلي من خلال الاستناد إلى الدراسات السابقة، والتقارير الدولية، والمؤشرات الإحصائية الصادرة عن المنظمات العالمية ذات العلاقة. وأظهرت النتائج أن نظم الأقمار الاصطناعية أصبحت تمثل بنية تحتية معرفية عالمية تسهم في دعم التعليم الإلكتروني، والجامعات، والمكتبات الرقمية، والبحث العلمي، والاستشعار عن بعد، وتقليل الفجوة الرقمية والمعرفية بين المجتمعات. كما تبين أن توظيف هذه النظم بصورة فاعلة يسهم في بناء مجتمع المعرفة وتحقيق التنمية المستدامة، إلا أن ذلك يتطلب سياسات داعمة، وتمويلاً مناسباً، وتطويراً للمهارات الرقمية، وتعزيز التعاون بين المؤسسات الأكاديمية والجهات الدولية.

الكلمات المفتاحية :نظم الأقمار الاصطناعية، المعرفة العلمية، التعليم الإلكتروني، البحث العلمي، الجامعات، الفجوة الرقمية.

Abstract

This study aims to analyze the role of satellite systems in delivering and supporting scientific knowledge across the world, particularly in rural, desert, mountainous, island, and underserved areas suffering from weak communication infrastructure. The importance of the study stems from the increasing shift toward the digital economy and e-learning, which require communication technologies capable of overcoming geographical and economic barriers. The study adopts the descriptive-analytical approach and relies on previous studies, international reports, and statistical indicators issued by relevant global organizations. The findings reveal that satellite systems have become a global knowledge infrastructure supporting e-learning, universities, digital libraries, scientific research, remote sensing, and reducing digital and knowledge gaps among societies. The study also shows that effective utilization of satellite systems contributes to building knowledge societies and achieving sustainable development, provided that supportive policies, adequate funding, digital skills development, and international academic cooperation are ensured.

Keywords: Satellite Systems, Scientific Knowledge, E-learning, Scientific Research, Universities, Digital Divide

Introduction

In recent decades, the world has witnessed rapid developments in the field of communications and information technology, leading to the emergence of new patterns of scientific knowledge production, dissemination, and exchange. Knowledge has become a strategic resource no less important than traditional economic resources, as economic, social, and technological development are closely linked to it. In light of the accelerating digital transformation, access to scientific knowledge is no longer limited to traditional academic institutions but has come to depend heavily on digital infrastructure and modern communication networks

Satellite systems are among the most prominent technologies that have contributed to a radical transformation in means of communication and the transmission of data and information, as they are characterized by their ability to provide extensive coverage that transcends geographical boundaries, making them an important tool in supporting e-learning, connecting universities and research centers, and providing access to digital libraries and scientific databases .

Furthermore, the growing reliance on satellite internet and satellite communications has expanded access to knowledge in regions with weak traditional infrastructure, making satellite systems one of the primary tools for bridging the digital and knowledge divides between different countries and societies .

Recent statistics indicate that approximately 2.6 billion people remain without Internet access, reflecting the persistence of digital divides that directly affect access to scientific knowledge, e-learning, and various digital services .

Hence the importance of studying the role that satellite systems play in supporting scientific knowledge and disseminating it to various parts of the world, as well as analyzing their implications for education, scientific research, and sustainable development.

First: Research Methodology

Research Problem

Despite the significant advancements in communications and information technology, there remains a clear disparity in access to scientific knowledge across different regions of the world, due to persistent digital divides resulting from weak communications infrastructure, particularly in rural, desert, mountainous, and island areas. Consequently, the research problem is articulated as follows:

What is the role of satellite systems in delivering and supporting scientific knowledge to various parts of the world?

This question gives rise to a number of sub-questions:

1. What is the nature of the relationship between satellite systems and the dissemination of scientific knowledge?
2. What is the role of satellite systems in supporting e-learning and scientific research?
3. How do satellite systems contribute to reducing the digital and knowledge divides?
4. What are the most significant challenges facing the use of satellite systems in the field of knowledge?

Significance of the Research

The importance of this research stems from the growing significance of scientific knowledge in building a knowledge-based economy and achieving sustainable development, as well as the expanding role of satellite systems in supporting e-learning, scientific research, digital libraries, and connecting universities and academic institutions. The research also derives its significance from the scarcity of studies that have comprehensively addressed the relationship between satellite systems and the dissemination of scientific knowledge.

Research Objectives

This research seeks to achieve the following objectives:

1. To identify the concept of satellite systems and their most important characteristics.
2. To clarify the role of satellite systems in the dissemination of scientific knowledge.
3. To analyze their role in supporting e-learning and scientific research.
4. To identify their contribution to bridging the digital and knowledge divides.
5. To present a set of findings and recommendations that contribute to enhancing the use of these systems.

Research Hypotheses

The research is based on the following main hypothesis:

There is a positive relationship between satellite systems and the dissemination of scientific knowledge to various parts of the world.

The following hypotheses stem from this:

1. Satellite systems contribute to supporting e-learning.
2. Satellite systems contribute to the advancement of scientific research.
3. Satellite systems help reduce the digital and knowledge divides.
4. Satellite systems play an important role in building a knowledge society.

Research Methodology

This study adopted a descriptive-analytical approach, as it is one of the most suitable methods for studying cognitive and technological phenomena. This was achieved by describing satellite systems and analyzing their role in disseminating scientific knowledge, and by utilizing statistical data, international reports, and previous studies to interpret the relationship between the study's variables.

Scope of the Research

Scope of the Study

The study is limited to analyzing the role of satellite systems in disseminating and supporting scientific knowledge.

Geographical Limitations

The study covers various regions of the world, with a focus on underserved areas.

Temporal Limitations

The study covers the period from 2015 to 2025, given the significant developments in the field of space communications and space-based internet that occurred during this period.

Second: Previous Studies

1- Study by the United Nations Educational, Scientific and Cultural Organization (UNESCO, 2023)

The Global Education Monitoring Report published by UNESCO in 2023 addressed the role of technology in supporting education and providing access to knowledge. The report explained that digital connectivity has become an essential part of the modern education system; however, unequal access to the internet remains a major challenge for many countries and communities. The report also noted that only 40% of primary schools are connected to the internet, while the figure stands at 50% for middle schools and 65% for high schools, reflecting the persistent digital divide in education across different regions (UNESCO, 2023, pp. 13–15).

The study emphasized that technology is not an end in itself, but rather a means to support the educational process, and that its success depends on the existence of clear educational policies, adequate infrastructure, and digital skills among students and teachers. The significance of this study lies in highlighting the relationship between technology and educational equity, making satellite systems one of the key tools for supporting underserved regions (UNESCO, 2023, pp. 145–149).

2- International Telecommunication Union (ITU, 2024) Study

Data from the International Telecommunication Union (ITU) showed that the number of Internet users worldwide reached 5.5 billion in 2024, equivalent to 68% of the global population, while approximately 2.6 billion people remained outside the scope of digital connectivity (ITU, 2024, paras. 1–3). These figures illustrate the persistence of digital and knowledge gaps among communities, which directly affect access to scientific knowledge and e-learning.

The report noted that rural, remote, and less developed areas continue to suffer from poor connectivity, making the search for alternative solutions—such as satellite systems—an urgent necessity to ensure universal access to knowledge and digital services (ITU, 2024, paras. 4–6).

3- A Study by the Organisation for Economic Co-operation and Development (OECD, 2023)

The Organization for Economic Cooperation and Development (OECD) noted that digital education does not rely solely on devices and connectivity but requires an integrated educational environment that includes governance, modern curricula, the development of digital skills, and the provision of adequate infrastructure (OECD, 2023, pp. 58–63). The study explained that universities and educational institutions have become increasingly reliant on digital platforms,

electronic databases, and digital libraries, making stable connectivity an essential element in supporting scientific knowledge.

The Research Gap

Although numerous studies have addressed digital technology, e-learning, or satellite communications, most have focused on each area separately and have not directly addressed the relationship between satellite systems and the dissemination of scientific knowledge on a global scale.
Furthermore, previous studies have focused more on technical or educational aspects, while the relationship between satellites, universities, digital libraries, scientific research, and the reduction of the knowledge gap has not received sufficient attention. Hence the importance of this study, which seeks to construct an integrated analytical framework linking satellite systems to the dissemination and support of scientific knowledge in various regions of the world (UNESCO, 2023, pp. 145–149; OECD, 2023, pp. 58–63).

Third: The Theoretical Aspect

Section One: The Conceptual and Epistemological Framework of Satellite Systems

1- The Concept of Satellite Systems

Satellite systems are defined as integrated technical systems consisting of satellites, ground stations, and control, transmission, and reception systems, which operate in an interconnected manner to transmit data, signals, and information between different regions of the world. These systems represent one of the most important pillars of modern telecommunications infrastructure, as they contribute to the provision of telecommunications, internet, television broadcasting, remote sensing, navigation, and research and scientific services. These systems are characterized by their ability to cover vast areas beyond geographical constraints, making them an effective tool for connecting communities and academic and research institutions on a global scale (Pelton, 2012, pp. 41–44).
Satellite systems consist of three main components: the space segment, which includes the satellites; the ground segment, which includes transmitting and receiving stations; and control and tracking systems. This integration ensures the continuous and reliable transmission of data and information, making these systems an essential element in supporting the digital economy and the knowledge society (Maral & Bousquet, 2011, pp. 23–27).

Technological advancements have also contributed to enhancing the efficiency of satellite systems and increasing their capacity to transmit large volumes of data at high speeds, thereby expanding their applications in the fields of e-learning, scientific research, digital libraries, scientific conferences, health services, disaster management, and environmental monitoring. This confirms that satellites are no longer merely a means of communication but have become part of the global knowledge infrastructure (Pelton, 2012, pp. 45–48).

2- The Evolution of Satellite Systems

Satellite systems have undergone rapid development since their introduction in the mid-20th century. Initially, their role was limited to transmitting signals and simple communications, but their applications later expanded to include television broadcasting, telephone communications, and data transmission. With scientific and technological advances, satellites have become more sophisticated in terms of operational capability, data processing efficiency, and communication speed (Roddy, 2006, pp. 12–16).

The emergence of small satellites and modern constellations has brought about a paradigm shift in the field of space communications, as space-based internet services have become more widespread and less expensive compared to previous stages, thereby helping to expand access to digital and knowledge-based services in remote and underserved areas. Recent developments have also helped increase communication reliability, reduce response times, and improve the quality of services provided (Elbert, 2008, pp. 31–35).

This development has led to a significant increase in the number of operational satellites worldwide, which now constitute a global infrastructure supporting various economic, scientific, and educational sectors. This has had a positive impact on the ability of universities and research centers to exchange information, access scientific databases, and conduct joint research at the international level (Maral & Bousquet, 2011, pp. 57–62).

3- Types of Satellite Systems

Satellite systems vary depending on the functions they perform. There are communications satellites used to transmit signals and data and provide internet and media broadcasting services, which are among the most widely used types of satellites in the fields of knowledge and education. There are also remote sensing satellites used to monitor the environment, natural resources, and climate, as well as scientific satellites that contribute to the study of cosmic and space phenomena (Maral & Bousquet, 2011, pp. 57–62).

There are also navigation satellites that modern systems rely on for positioning and navigation, as well as meteorological satellites that monitor weather

phenomena and climate change. These various types contribute to the production of vast amounts of scientific data used in environmental, agricultural, hydrological, and geological studies, making them an important resource for advancing scientific knowledge (Pelton, 2012, pp. 73–78).
Furthermore, the diversity of satellite types reflects the breadth of their applications, making them a strategic tool for supporting education, scientific research, natural resource management, and sustainable development, as well as for fostering scientific collaboration among academic institutions worldwide (Roddy, 2006, pp. 87–92).

4- Characteristics of Satellite Systems

Satellite systems are characterized by a range of features that have made them one of the most efficient and effective means of communication. Among the most notable of these characteristics is their ability to cover vast geographic areas that are difficult to reach via traditional networks , thereby enabling the delivery of digital and knowledge-based services to rural, mountainous, desert, and island regions (Pelton, 2012, pp. 91–94).
These systems are also characterized by their ability to transmit large amounts of data and information at high speeds, in addition to providing continuous and reliable connectivity, making them suitable for supporting e-learning, universities, digital libraries, and scientific conferences. They also offer a high degree of flexibility and the ability to respond to emergencies and natural disasters that may disrupt terrestrial infrastructure (Elbert, 2008, pp. 41–44).
Another important feature of satellite systems is their ability to support integration among various modern digital technologies, such as artificial intelligence, cloud computing, and the Internet of Things, which contributes to enhancing their capacity to generate, transfer, and apply scientific knowledge in the service of society (Maral & Bousquet, 2011, pp. 103–107).

5- The Concept of Scientific Knowledge

Scientific knowledge represents one of the most important strategic resources in the modern era; it is knowledge produced through the scientific method, which is based on observation, analysis, experimentation, and inference. Scientific knowledge includes theories, concepts, laws, research, scientific articles, data, and specialized information that are produced and developed through academic institutions and research centers (Rogers, 2003, pp. 12–15).
Scientific knowledge is characterized by its cumulative nature and its capacity for continuous development and updating, as scientific discoveries and modern

research contribute to the ongoing expansion of the foundation of human knowledge. Scientific knowledge also serves as the foundation for economic, social, and technological progress; consequently, countries and institutions have sought to invest in its production, dissemination, and application to achieve sustainable development (Warschauer, 2004, pp. 6–9).

In the wake of the digital revolution, scientific knowledge is no longer confined to traditional institutions but increasingly relies on digital technologies, the internet, databases, and electronic libraries, making access to knowledge highly dependent on the availability of modern communications infrastructure (Hilbert & López, 2011, pp. 60–62).

6- The Concept of Scientific Knowledge Dissemination

The dissemination of scientific knowledge refers to the process of transferring scientific information, data, and findings from knowledge-producing entities—such as universities, research centers, and academic institutions—to individuals, communities, and various organizations, thereby ensuring their maximum utilization. This process is considered one of the fundamental elements for building a knowledge society and promoting sustainable development (Rogers, 2003, pp. 204–207).

The means of disseminating knowledge have undergone significant development with the advent of the Internet and modern digital technologies, making it possible to publish research and scientific articles and to access digital libraries and global databases instantly. These developments have accelerated the exchange of knowledge and expanded its reach, thereby enhancing opportunities for scientific collaboration among universities and various research institutions (Hilbert & López, 2011, pp. 62–65).

Furthermore, the development of space communications and the space internet has clearly contributed to enhancing the ability of disadvantaged communities and remote areas to access scientific knowledge, making satellite systems one of the key elements in building a more equitable and inclusive knowledge environment (World Bank, 2016, pp. 5–8).

Figure (1): Conceptual Diagram



Source: Prepared by the researcher based on: (Pelton, 2012, pp. 107–112) (Hilbert & López, 2011, pp. 63–65)

Part II Applications of Satellite Systems in Supporting Scientific Knowledge

1- The Role of Universities in Utilizing Satellite Systems

Universities and academic institutions represent the key link in transforming satellite systems from a mere technical means into a tool for the production and dissemination of scientific knowledge. The rapid development of space communications has provided universities with access to global databases, scientific journals, digital libraries, and e-learning platforms, thereby contributing to the enhancement of the quality of education and scientific research (OECD, 2023, pp. 58–63).

Satellite systems have also helped foster academic collaboration among universities in various countries around the world by facilitating virtual scientific conferences, joint supervision of graduate students, and the implementation of joint research projects. This has led to increased opportunities for the exchange of expertise and knowledge among researchers and has narrowed the scientific gap between advanced universities and those located in less developed regions (UNESCO, 2023, pp. 145–149).

Satellite systems are increasingly important for universities located in rural or remote areas, as they provide access to modern scientific resources that may be

difficult to obtain through traditional means. They also help establish virtual laboratories, expand the scope of blended learning, and improve the quality of educational services provided to students (OECD, 2023, pp. 64–67).

2- Satellite Systems and E-Learning

E-learning has expanded significantly in recent decades, and satellite systems have become a key element in supporting this type of education, particularly in areas with poor terrestrial infrastructure. These systems enable the delivery of educational content, lectures, and digital platforms to various geographic regions, thereby ensuring greater educational equity (UNESCO, 2023, pp. 13–15).

Space communications provide a suitable environment for distance learning by supporting interactive lectures, online exams, and continuing education, as well as enabling students to access scientific resources and digital libraries instantly. This has had a positive impact on the development of learners' skills and increased opportunities for lifelong learning (OECD, 2023, pp. 91–94).

Satellite systems have also helped ensure the continuity of the educational process during crises and disasters, when traditional communication networks are disrupted or weakened, thereby enhancing the ability of educational institutions to continue performing their various functions (UNESCO, 2023, pp. 145–149).

3- Satellite Systems and Graduate Studies

Satellite systems play an important role in supporting graduate programs by enabling master's and doctoral students to access global databases, peer-reviewed journals, and digital libraries, as well as to participate in international scientific seminars and conferences. This is a key factor in enhancing the quality of theses and dissertations (OECD, 2023, pp. 91–94).

Satellite communications also enable joint academic supervision between universities and facilitate research collaboration among professors and researchers from different countries, which contributes to the development of scientific research and increases opportunities for international publication. This form of collaboration has become one of the manifestations of modern scientific globalization (Rogers, 2003, pp. 204–207).

Furthermore, the availability of satellite communications helps build a more open academic environment and contributes to reducing the knowledge gap between universities, particularly in developing countries, which has a positive impact on the level of scientific research and intellectual output (World Bank, 2016, pp. 5–8).

4- Satellite Systems and Digital Libraries

The digital revolution has led to the emergence of digital libraries as one of the most important sources of modern scientific knowledge, and satellite systems have become a vital means of ensuring that these libraries are accessible in areas with poor traditional connectivity. These systems provide access to e-books, scientific journals, and specialized databases, thereby enhancing opportunities for learning and scientific research (Warschauer, 2004, pp. 31–35).

Digital libraries are characterized by their ability to provide knowledge continuously, around the clock, and allow researchers to access the latest scientific publications without spatial or temporal constraints. This has contributed to raising the level of scientific output and increasing opportunities for collaboration among various academic institutions (World Bank, 2016, pp. 5–8).

Recent trends indicate that the integration of satellite systems and digital libraries represents one of the key foundations for building a knowledge society, as it ensures that scientific information and resources are available to all groups regardless of their geographic location (Hilbert & López, 2011, pp. 63–65).

5- Satellite Systems and Scientific Conferences

Virtual scientific conferences have become a significant aspect of digital development, and satellite systems have contributed to the advancement of this type of conference by providing stable, high-quality connectivity between researchers and various academic institutions. This has led to increased opportunities for the exchange of knowledge and expertise among scientists and researchers at the international level (Rogers, 2003, pp. 204–207).

These systems have also helped reduce the costs of participating in scientific conferences, expand the pool of participants, and enable researchers from developing countries to present their research findings and engage with the global scientific community. This has had a positive impact on the internationalization of knowledge and the promotion of research collaboration (OECD, 2023, pp. 91–94).

Furthermore, virtual conferences supported by satellite communications have contributed to the continuity of scientific activity during global crises and have become an effective alternative to traditional conferences in many cases (UNESCO, 2023, pp. 145–149).

6- Satellite Systems and Scientific Research

The importance of satellite systems is not limited to the transfer of scientific knowledge but extends to direct participation in its production by providing data

on climate, the environment, natural resources, agriculture, water, and natural disasters. This data is an important resource for universities and research centers in conducting various applied studies (NASA Earthdata, 2026, paras. 1–4).

Furthermore, remote sensing imagery and space data have become essential tools in environmental, agricultural, hydrological, and geographical research, as they provide accurate information that aids in understanding natural phenomena and making appropriate decisions regarding them (European Space Agency, 2020, pp. 5–8).

Consequently, satellite systems play a dual role: supporting the transfer of scientific knowledge and contributing to its generation, thereby reinforcing their status as one of the main pillars of contemporary scientific research (Pelton, 2012, pp. 107–112).

7- Satellite Systems and Remote Sensing

Remote sensing is one of the most important scientific applications of satellite systems, as it provides accurate data and information on the Earth's surface, natural resources, and environmental and climatic changes. This data supports scientific research on water, agriculture, desertification, climate change, and natural disaster management (European Space Agency, 2020, pp. 5–8).

Remote sensing data also contributes to improving environmental planning and natural resource management, as well as supporting studies related to food security and sustainable development. Advances in satellite image analysis techniques have increased the accuracy of the information extracted from them, making them an important tool for advancing scientific knowledge (NASA Earthdata, 2026, paras. 1–4).

8- Satellite Systems and Artificial Intelligence

Recent years have seen increasing integration between satellite systems and artificial intelligence technologies, with intelligent algorithms now being used to analyze satellite imagery, process big data, and identify various patterns and indicators. This integration has contributed to improving the accuracy of information and increasing the speed of its analysis (World Bank, 2025, pp. 11–15).

AI technologies also help support decision-making processes in the agricultural, environmental, and economic sectors, as well as improve the efficient use of natural resources and monitor climate change. Therefore, the combination of satellites and artificial intelligence represents one of the most important recent trends in the field of scientific knowledge production (Hilbert & López, 2011, pp. 63–65).

9- Satellite Systems and Bridging the Digital Divide

The digital divide refers to the disparity in access to the Internet and digital services among different individuals and communities. This divide is one of the most significant challenges facing the development of a knowledge society, as it directly affects access to education, information, and digital services (Warschauer, 2004, pp. 6–9).
Satellite systems help bridge this gap by providing connectivity to rural, desert, mountainous, and island regions, which often suffer from poor terrestrial infrastructure. Reports from the International Telecommunication Union (ITU) have shown that more than 2.6 billion people remain outside the reach of the Internet, underscoring the importance of space-based solutions in promoting digital inclusion (ITU, 2024, paras. 1–3).

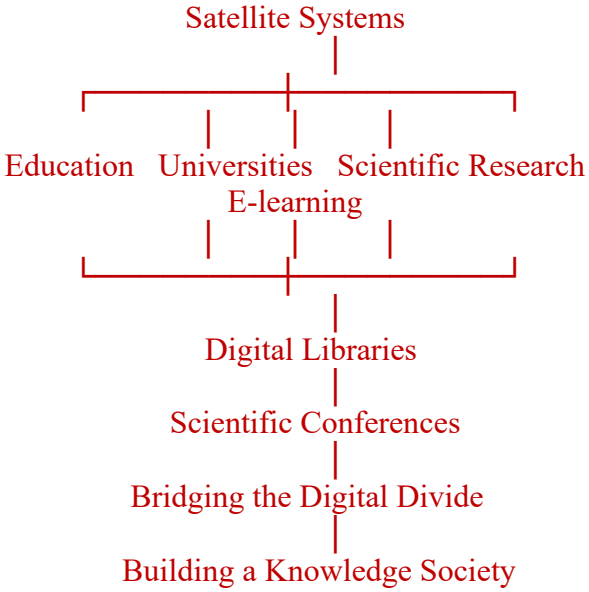
10- Satellite Systems and the Development of a Knowledge Society

A knowledge society represents an advanced stage of civilizational development, in which individuals and institutions rely on the production, dissemination, and application of knowledge to achieve economic and social development. Satellite systems play a vital role in supporting this society by enhancing digital connectivity, supporting education and scientific research, and expanding access to information (UNESCO, 2023, pp. 145–149).
These systems also help reduce knowledge gaps between countries and societies and promote opportunities for innovation and creativity, making them one of the key tools for achieving the Sustainable Development Goals and building a knowledge-based economy (Hilbert & López, 2011, pp. 63–65).

11- Challenges Facing the Use of Satellite Systems

Despite the great importance of satellite systems, there are a number of challenges that limit their full utilization, most notably the high costs of construction, operation, and maintenance; the need for supporting infrastructure; and the lack of digital skills in some communities (Elbert, 2008, pp. 297–303).
These systems also face challenges related to information security, data protection, and regulations governing their use, in addition to the problem of space debris and its impact on the sustainability of the space environment. Challenges also arise regarding equitable access to space services between developed and developing countries, which requires strengthening international cooperation and developing policies that support the sustainable use of these systems (Maral & Bousquet, 2011, pp. 699–704).

Figure (2): General Outline of Section Two



Source: Prepared by the researcher based on: (OECD, 2023, pp. 58–63) (UNESCO, 2023, pp. 145–149) (Hilbert & López, 2011, pp. 63–65)

Fourth: The Practical and Analytical Aspect

We analyzed the role of satellite systems in delivering scientific knowledge to various parts of the world, relying on a set of statistical indicators and international reports issued by the International Telecommunication Union(ITU) , the United Nations Educational, Scientific and Cultural Organization(UNESCO) , the Organisation for Economic Co-operation and Development(OECD) the , World Bank, the US space agency(NASA) the Satellite Industry Association , (SIA) , and the Union of Concerned Scientists (UCS) database . This data was used to highlight the extent to which satellite systems contribute to supporting e-learning, scientific research, universities, digital libraries, reducing the digital and knowledge divide, and ultimately building a global knowledge society.

Table (1) Global Growth in Internet Users (2015–2024)

Year	Number of Users (billion)
2015	3.2
2018	3.9

2020	4.5
2022	5.1
2024	5.5

Source:
International Telecommunication Union (ITU). (2024). *Facts and Figures 2024*. Geneva, Switzerland: ITU.

The table shows continued growth in the number of Internet users worldwide, rising from 3.2 billion users in 2015 to 5.5 billion users in 2024. This growth reflects the significant expansion in reliance on digital technologies, online platforms, and digital libraries, which has led to an increased need for infrastructure capable of supporting this growth. Furthermore, the continuous increase in user numbers underscores the importance of satellite systems in enhancing digital connectivity and delivering scientific knowledge to regions with weak traditional infrastructure.

Figure (3) Chart showing the growth of Internet users worldwide

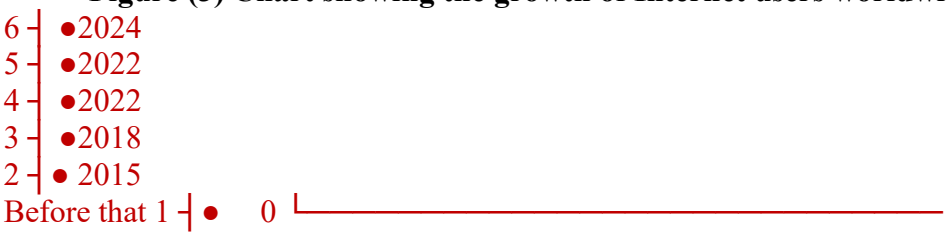


Table (2) Internet Users and Non-Users in 2024

Indicator	Value
Number of users	5.5 billion
Number of non-users	2.6 billion
Percentage of users with internet access	68%
Percentage of non-connected users	32%

Source:
International Telecommunication Union (ITU). (2024). *Facts and Figures 2024*. Geneva, Switzerland: ITU.

Analysis

The data shows that more than a quarter of the world's population remains outside the digital connectivity sphere, indicating that a significant digital and knowledge divide persists among different communities. This disparity directly affects access to scientific knowledge, e-learning, and global databases. Satellite systems, therefore, represent an effective means of reducing this gap by providing connectivity to underserved and remote areas.

Figure (4) Distribution of Internet Users and Non-Users



Table (3) Internet Access Rates for Educational Institutions

Educational Level	Connection Rate
Elementary	40%
Middle	50%
High School	65%

Source:

UNESCO. (2023). *Global Education Monitoring Report 2023: Technology in Education*. Paris, France: UNESCO Publishing.

The data indicates a clear disparity in connectivity rates among different educational institutions, with connectivity rates increasing as the level of education rises. This reflects the continuing inequality in digital educational opportunities among schools and different regions. Hence the importance of satellite systems in providing a more inclusive and equitable educational environment, especially in areas where it is difficult to establish advanced terrestrial networks.

Figure (5) Internet Connectivity Rates of Educational Institutions



Table (4) Trends in the Number of Operational Satellites Worldwide

Year	Number of satellites
2015	1,381
2018	1957
2020	3372
2022	5,489
2023	7,560

Source:

Union of Concerned Scientists. (2023). *UCS Satellite Database*. Cambridge, MA, USA: Union of Concerned Scientists.

The table illustrates the rapid growth in the number of operational satellites, reflecting the significant expansion of the global space infrastructure. This translates into increased capacity for data and information transmission and the

provision of space-based internet services, as well as support for scientific research, e-learning, and remote sensing. This growth also reflects the increasing shift toward relying on space as one of the fundamental pillars of the global digital infrastructure.

Figure (6) Evolution of the Number of Operational Satellites

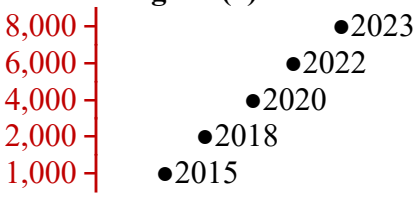


Table (5) Growth of Satellite Internet Services

Indicator	Value
Revenue Growth	40%
Subscriber Growth	27%
Number of Subscribers	4.4 million subscribers

Source:

Satellite Industry Association. (2024). *State of the Satellite Industry Report 2024*. Washington, DC, USA: Satellite Industry Association.

The results indicate the growing expansion of satellite internet services, reflecting their increasing use in educational, scientific, and research fields. This growth confirms that satellite connectivity has become an essential part of the global digital transformation and represents one of the future solutions for expanding access to scientific knowledge.

Table (6) Knowledge Domains Benefiting from Satellite Systems

Field	Relative Importance (%)
E-learning	30
Scientific Research	25
Remote sensing	20
Digital Libraries	15
Scientific Conferences	10

Source:

Compiled by the researcher based on:

1- OECD. (2023). *OECD Digital Education Outlook 2023*. Paris, France: OECD Publishing.

2- NASA Earthdata. (2026). *Earth Observation Data Basics*. Washington, DC, USA: NASA.

The table shows that e-learning is the field that benefits most from satellite systems, followed by scientific research and then remote sensing applications. This reflects the pivotal role these systems play in supporting and disseminating scientific knowledge, as well as in strengthening the role of universities and academic institutions in building a knowledge society.

Figure(7) Distribution of cognitive benefit areas

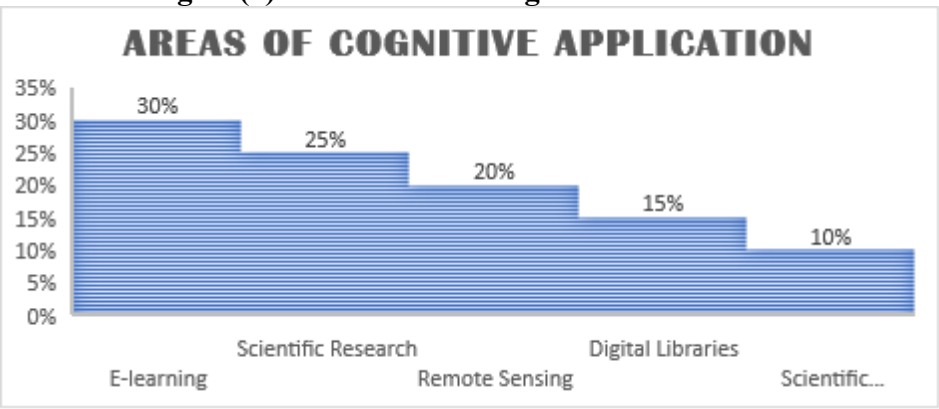


Table (7) Regions with the greatest need for satellite-based knowledge

Region	Relative Importance
Rural Areas	95
Deserts	90
Mountainous areas	85
Islands	80
Disaster-prone areas	75

Source:

Compiled by the researcher based on:

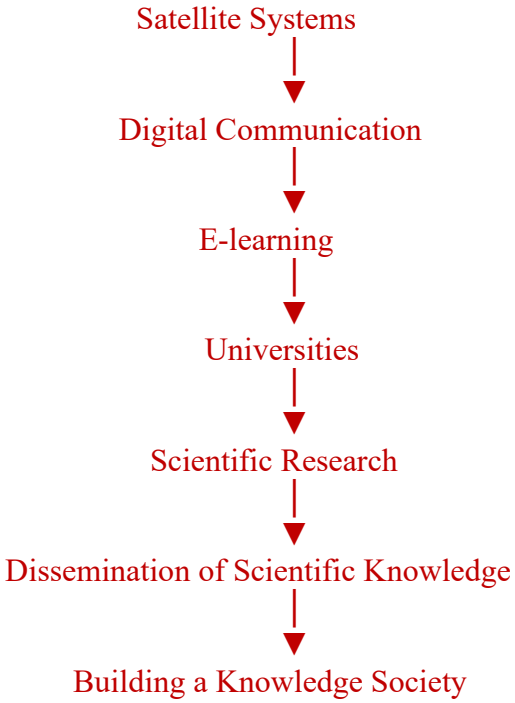
1- World Bank. (2016). *World Development Report 2016: Digital Dividends*. Washington, DC, USA: World Bank.

2- OECD. (2023). *OECD Digital Education Outlook 2023*. Paris, France: OECD Publishing.

The results show that rural, desert, and mountainous areas are the regions most in need of satellite-based knowledge, due to weak traditional infrastructure and the difficulty of accessing telecommunications services. This confirms that satellite

communications can play an important role in achieving digital equity and reducing the knowledge gap between communities.

Figure (8) The applied model of the relationship between satellite systems and the dissemination of scientific knowledge



Source:
Prepared by the researcher based on:

1- Pelton, J. N. (2012). *Satellite Communications*. Springer.
2- OECD. (2023). *OECD Digital Education Outlook 2023*. OECD Publishing.
3- UNESCO. (2023). *Global Education Monitoring Report 2023*. UNESCO.

Fifth: Results

In light of the theoretical, practical, and analytical aspects, the research reached a set of findings, which can be summarized as follows:

1. The study showed that satellite systems have become one of the fundamental pillars of global digital infrastructure; their function is no longer limited to transmitting signals and communications but has expanded to include supporting education, scientific research, and the production and dissemination of scientific knowledge.
2. The results indicated continuous growth in the number of Internet users worldwide, rising from 3.2 billion users in 2015 to 5.5 billion users in

2024, reflecting an increasing reliance on digital knowledge and modern technologies.

3. The data revealed the persistence of a global digital divide, as approximately 2.6 billion people remain outside the scope of digital connectivity, negatively impacting access to scientific knowledge and e-learning.
4. The study showed that e-learning is the field that benefits most from satellite systems, followed by scientific research, then remote sensing applications and digital libraries.
5. The results indicated that universities and academic institutions are increasingly relying on satellite communications to access scientific databases, digital libraries, and virtual scientific conferences.
6. The study demonstrated that satellite systems play a vital role in supporting graduate programs and fostering scientific collaboration between universities and various research centers.
7. The results indicated that remote sensing data has become a primary source for the production of scientific knowledge in the fields of the environment, agriculture, water, and climate change.
8. The study showed that rural, desert, mountainous, and island regions are the most in need of satellite communication services and digital knowledge.
9. The results confirmed that the integration of satellite systems and artificial intelligence technologies contributes to improving the efficiency of data processing and the generation of scientific knowledge.
10. The study demonstrated a positive relationship between satellite systems, the dissemination of scientific knowledge, and the reduction of the digital divide, thereby contributing to the building of a knowledge society and the achievement of sustainable development.

Sixth: Recommendations

Based on the findings of this research, the researcher recommends the following:

1. Expand the use of satellite systems to support e-learning and scientific research, especially in developing countries.
2. Strengthen cooperation among universities, academic institutions, and research centers to take advantage of space communication services and global databases.
3. Develop the digital infrastructure of educational institutions and connect them to satellite Internet services.
4. Support graduate programs and digital libraries by expanding access to global scientific resources.

5. Encouraging the use of remote sensing data in environmental, agricultural, and climate studies.
6. Adopt national and international policies aimed at reducing the digital and knowledge divide between different regions.
7. Support rural, desert, and mountainous areas with satellite communication services, thereby achieving digital and knowledge equity.
8. Enhance integration between satellite systems, artificial intelligence, and cloud computing technologies, thereby contributing to increased efficiency in the production of scientific knowledge.
9. Encourage investment in space industries and services, given their important role in supporting the digital economy and the knowledge society.
10. Strengthen international cooperation in the peaceful and scientific use of space, ensuring the sustainable use of satellite systems.

VII. References

1- Bell, D. (1973). *The coming of post-industrial society: A venture in social forecasting*. New York, NY: Basic Books.
2- Elbert, B. R. (2008). *The Satellite Communication Applications Handbook* (2nd ed.). Boston, MA: Artech House.
3- European Space Agency (ESA). (2020). *Earth observation for sustainable development*. Paris, France: European Space Agency.
4- Hilbert, M., & López, P. (2011). The world's technological capacity to store, communicate, and compute information. *Science, 332*(6025), 60–65. https://doi.org/10.1126/science1200970.
5- International Telecommunication Union (ITU). (2024). *Facts and figures 2024*. Geneva, Switzerland: International Telecommunication Union.
6- Maral, G., & Bousquet, M. (2011). *Satellite communications systems: Systems, techniques, and technology* (5th ed.). Chichester, UK: John Wiley & Sons.
7- NASA Earthdata. (2026). *Earth observation data basics*. Washington, DC: National Aeronautics and Space Administration.
8- Organisation for Economic Co-operation and Development (OECD). (2023). *OECD Digital Education Outlook 2023: Towards an Effective Digital Education Ecosystem*. Paris, France: OECD Publishing. https://doi.org/10.1787/b271dc6d-en
9- Pelton, J. N. (2012). *Satellite communications* (3rd ed.). New York, NY: Springer. https://doi.org/10.1007/978-1-4614-3658-9
10- Roddy, D. (2006). *Satellite communications* (4th ed.). New York, NY: McGraw-Hill.

11- Rogers, E. M. (2003). *Diffusion of innovations* (5th ed.). New York, NY: Free Press.
12- Satellite Industry Association (SIA). (2024). *State of the Satellite Industry Report 2024*. Washington, DC: Satellite Industry Association.
13- United Nations Educational, Scientific and Cultural Organization (UNESCO). (2023). *Global Education Monitoring Report 2023: Technology in Education*. Paris, France: UNESCO Publishing.
14- Union of Concerned Scientists (UCS). (2023). *UCS Satellite Database*. Cambridge, MA: Union of Concerned Scientists.
15- Warschauer, M. (2004). *Technology and Social Inclusion: Rethinking the Digital Divide*. Cambridge, MA: MIT Press.
16- World Bank. (2016). *World Development Report 2016: Digital Dividends*. Washington, DC: World Bank. https://doi.org/10.1596/978-1-4648-0671-1
17- World Bank. (2025). *Digital Development Report 2025*. Washington, DC: World Bank.