Innovation and Technology for Sustainable Development

Promising prospects in the Arab region for 2030

Extended Summary
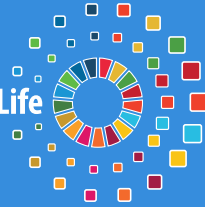
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Economic and Social Commission for Western Asia (ESCWA)

Innovation and technology for sustainable development:

Promising prospects in the Arab region for 2030

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Acknowledgments

CONTENTS

Introduction

Technology and innovation play a key role in achieving inclusive sustainable development. Studies prepared before and after the launch of the 2030 Agenda for Sustainable Development have highlighted the contribution of science, technology and innovation (STI) to development. Once the complexities of the Sustainable Development Goals (SDGs) became apparent, STI became a crucial tool for achieving those Goals within the framework of the knowledge revolution and rapid technological development. SDG 9 focuses on building resilient infrastructure, stimulating inclusive and sustainable industry, and encouraging innovation. Innovation is also a fundamental element in most SDGs related to health, wellbeing, education, gender equality, decent work and economic growth, sustainable cities and communities, climate change and the environment, peace, justice and strong institutions, and partnerships.

The present report is a summary of a study that emphasizes the importance of new innovation and technology approaches in development policies to achieve the SDGs. It provides an overview of the 2030 Agenda, its 17 Goals, and the key role of STI in achieving the SDGs and overcoming challenges in the Arab region. The study reviews the concept of innovation and its impact on populations' wellbeing once it is transformed from a scientific definition to a more flexible concept covering a wide range of activities, from discovery to the practical application of new knowledge. New innovation approaches, in addition to the traditional linear approach, include task-oriented innovation, social innovation, inclusive innovation, grassroots innovation, open and collaborative innovation, and reverse innovation. The study includes assessments of the contribution of each of these approaches to the achievement of the SDGs in the Arab region, and the success factors of each approach when used in innovation policies. The study examines the link between innovation and technology, particularly at the dawn of a sweeping industrial revolution led by the following four technology groups: materials technology, digital technology, biotechnology, and energy and environmental technology. It analyses the impact of these groups on the social, economic and environmental aspects of life, and reviews some of the most promising technologies for the Arab region, such as artificial intelligence, the Internet of Things and robots.

The study presents four sets of recommendations for Arab countries to integrate STI into their national plans to achieve the 2030 Agenda, in line with their potential and their expectations of science and technology for sustainable economic, social and environmental development.

I. THE 2030 AGENDA AND INNOVATION AND TECHNOLOGY

The SDGs are interdependent and integrated in nature. They were designed to interact among themselves, meaning that each Goal should be achieved in parallel with the others, thus increasing their impact. Strategies and approaches should be designed with the same level of balance and integration evident in these Goals and their cross-cutting economic, social and environmental dimensions. The integrated and global nature of the SDGs has resulted in a significant shift from the Millennium Development Goals, which were simply an agenda for development cooperation benefiting least develop countries, and an implicit transformation from the 'business-as-usual' approach that is no longer valid for achieving the SDGs. What makes the 2030 Agenda and the SDGs truly transformative is that they call on all countries, whether developing or developed, to act and transform so as to jointly pursue a sustainable development path.

A. IMPLEMENTATION OF THE SDGS IN ARAB COUNTRIES

Most Arab countries still have a long way to go to implement the SDGs, as indicated in table 1. Moreover, all Arab countries need to make intense efforts to achieve Goal 9, which is directly linked to technology and innovation.

TABLE 1. SDG IMPLEMENTATION IN THE ARAB REGION

Countries	No poverty	Zero hunger	Good health and wellbeing	Quality education	Gender equality	Clean water and sanitation	Affordable, clean energy	Decent work and economic growth	Industry, innovation and infrastructure	Reduced inequalities	Sustainable cities and communities	Responsible consumption and production	Climate action	Life below water	Life on land	Peace, justice and strong institutions	Partnerships for the SDGs
Algeria																	
Bahrain																	
Egypt																	
Iraq																	
Jordan																	
Kuwait																	
Lebanon																	
Libya																	
Morocco																	
Oman																	
Qatar																	
Saudi Arabia																	
Sudan																	
Syrian Arab Republic																	
Tunisia																	
United Arab Emirates																	
Yemen																	

Source: Bertelsmann Stiftung and the Sustainable Development Solutions Network, 2018.

Note: Green cells indicate maximum progress in each indicator and the minimum required to achieve the SDGs. The yellow, orange and red cells indicate gradual departure from achieving the SDGs. Grey cells indicate that data are not available.

Analysis of the status of implementation of the SDGs in Arab countries shows that food security and sustainable agriculture (Goal 2), and sustainable water management (Goal 6) are major challenges and priorities in most Arab countries. The results of many Arab countries are poor on gender equality (Goal 5), and there is a need for accurate data on income inequality (Goal 10) and data on income and wealth distribution in the region so as to guide policies. In recent years, many countries in the region, including those affected by conflict, have made progress in ending extreme poverty (Goal 1), improving health outcomes, and promoting clean and affordable energy (Goal 7). However, most countries in the region have faced difficulties in meeting environmental objectives, especially on climate action (Goal 13), underwater life (Goal 14), and terrestrial life (Goal 15). Most Arab countries also remain far from achieving Goal 9 on industry, infrastructure and innovation.

B. TRANSFORMATIONS NEEDED TO DEVELOP A NEW CONCEPTUAL FRAMEWORK FOR DEVELOPMENT IN THE ARAB REGION

1. *Transformations in international development cooperation*

SDG 17 focuses on strengthening the means of implementation and revitalizing global partnerships for achieving sustainable development. It is therefore important, in the next phase, to strengthen international cooperation for sustainable development and to transform partnerships among stakeholders in society, especially given the growing importance of partnerships with the private sector and civil society in the sustainable development field. Such partnerships should be built on new foundations, most importantly ensuring clarity and transparency in distributing roles and responsibilities among all stakeholders; defining the terms of reference for partnerships, including mutual accountability; and considering the cost-benefit balance.

Domestic and international partnership initiatives and projects in the field of sustainable development have been launched, and have become a common practice as a result of innovative international knowledge networks and platforms that offer further collaboration opportunities with public and private entities. These platforms include those created by the United Nations for sustainable development such as the SDG Partnerships for SDGs online platform[1] and the Technology Facilitation Mechanism. The WBCSD Low Carbon Technology Partnership Initiative of the World Business Council for Sustainable Development is a successful example of global innovation partnerships with more than 160 companies.[2]

2. *Transformations in governance*

There is a need for transformations in decision-making mechanisms related to development in Arab countries, notably adopting a participatory approach (a bottom-up approach) involving real actors, especially the public, communities and the private sector. Development should not be limited to a top-down approach, which often reflects only the views of decision makers.

Conforming the importance of a participatory approach in successfully completing development projects, several SDG targets call for social participation, including target 5.5. on gender equality, target 6.b on water, and target 11.3 on planning.

Another vital transformation in national, regional and international governance is to abandon the development and testing approach at the domestic level, and build on the successful experiences of other countries by adapting them to the national context.[3] Crowdsourcing techniques have emerged in recent years

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[1] https://sustainabledevelopment.un.org/partnerships/.

[2] https://www.wbcsd.org/Overview/Events/WBC-events/LCTPi-7.

[3] UNDP, 2016.

and have been adopted by the United Nations after proving their usefulness in finding the most effective solutions to problems at hand, particularly with regard to the 2030 Agenda.[4]

3. *Shifting towards cross-sectoral and interdisciplinary approaches*

This transformation derives its importance from SDG characteristics geared towards formulating a comprehensive development vision by adopting multisectoral and interdisciplinary approaches, which poses a major challenge to the sectoral methodology adopted in most countries, especially in developing countries. In the Arab region in particular, the mentality of alienation and isolation dominates both in ministries and government institutions and in university programmes and departments. The SDGs emphasize the adoption of a cross-disciplinary approach, which has proven its effectiveness at the academic, research and professional levels.[5] Interestingly, modern technology recommended for the achievement of the SDGs is, by nature, integrated and cross-disciplinary. The so-called integrated technological solutions approach has become a recent trend in this area.[6]

Multisectoral approaches are a major challenge, especially in the context of addressing complex sustainable development issues such as climate change, poverty, sustainable resource consumption, and the green economy. Achieving water, energy and food security in the Arab region, for example, is critical for sustainable development. Consequently, the so-called water-energy-food nexus has been adopted at the Arab regional level.[7]

4. *Shifting towards the adoption of systemic thinking*

A systematic approach is the best method to deal with complex problems and with the SDGs, because it adopts a holistic and integrated vision by applying system dynamics to linkages between environmental, social, economic or policy components. Systemic thinking requires a deep understanding of the systemic nature and the dynamics of interlinkages between many complex systems, such as the water, energy and food sectors and ecosystems, and an analysis of changes that could be caused by future threats, including climate change. A systematic approach could help overcome the challenges of the water-energy-food nexus in the Arab region, having been successfully implemented as part of a pilot project involving the water and sanitation sector in Sri Lanka with the assistance of the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP).[8]

5. *Transformations in the business sector*

Together with Government, business plays a crucial role in achieving sustainable development as a key player in contributing to the achievement of the SDGs and providing further innovation opportunities. Given the uncertainty in the business sector as a result of various crises globally, and particularly in the Arab region, business leaders face difficulties in clearly projecting the future and believe that the responsibility for achieving the SDGs is limited to Governments. In reality, those Goals provide a promising model for achieving long-term growth if both the public and private sectors work to achieve them.

Research has shown that the business system is influenced by global objectives, whose achievement requires private sector involvement. The economic returns of the SDGs will not be realized unless private

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[4] United Nations Sustainable Development Goals Knowledge Platform, 2016.

[5] Wernli and Darbellay, 2016.

[6] Global Science technology and innovation Conferences, 2017.

[7] E/ESCWA/SDPD/2015/2.

[8] ESCAP, 2017.

sector companies exploit trade opportunities that, in turn, help advance progress on all global objectives.[9,10] A study on the Middle East and North Africa (MENA) region shows that companies can receive a promising 'economic reward' if global objectives are met.[11] The private sector plays a vital role in the field of innovation and technology in terms of developing applications that suit development needs in various sectors, and in the localization and dissemination of technology in communities.

Consequently, business leaders should be involved in achieving the SDGs by integrating global objectives in growth strategies and value chains, as an alternative to corporate social responsibility.

II. INNOVATION FOR THE SUSTAINABLE DEVELOPMENT GOALS

The study reviews the innovation models that have evolved and diversified over the past decades, and showed that the practical and realistic method to define innovation models is to look at them as process models.[12] It also addresses the traditional linear model of innovation that coincided with the technological and industrial revolution in the middle of the twentieth century, and remained one of the fundamentals of innovation and technological and scientific development. Moreover, it reviews new flexible innovative approaches that could be used as tools to assist developing countries in achieving the SDGs, and identifies policy-level requirements for the dissemination and adoption of such approaches in the Arab region, including the following:

A. LINEAR INNOVATION MODEL

A linear model is the traditional innovation model, which represents the fundamental step on the innovation path for the majority of developed and developing countries. The innovation process started began with basic scientific research, and went through the stages of applied research and development to marketing. It played an important role in the development of technology strategies in most industrialized countries, and greatly assisted in technology development. The term 'development' includes product development and process development.

While economic growth is a measure of wellbeing and prosperity at the national level, it can be argued that living standards have been greatly influenced by innovation. Innovation processes can be used to achieve economic growth in the following two ways: technological competitiveness coupled with the creation of new products and new markets; and competitiveness in terms of innovation cost, replacement of human labour and industrial technology increases production flexibility and reduces costs.[13] In the Arab region, the landscape is more complicated because innovation underdevelopment, owing to lack of effective policies,[14] has had a negative impact on improved productivity, sustained economic growth, job creation for young people, and the environment.

B. MISSION-ORIENTED INNOVATION

This approach relies on guiding innovation through innovative tasks towards technological breakthroughs or solutions to major or intractable social challenges, such as climate change, unemployment, or problems arising from emergency crises, epidemics and disasters. Mission-oriented innovation policies can

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[9]   Price Waterhouse Cooper PwC, 2015.

[10]   Business and Sustainable Development Commission, 2017a.

[11]   Business and Sustainable Development Commission, 2017b.

[12]   Kotsemir and Meissner, 2013.

[13]   Petrariu, Bumbac and Ciobanu, 2013.

[14]   E/ESCWA/TDD/2017/TECHNICAL PAPER.1.

be defined as government systemic policies that rely on harnessing frontier knowledge to achieve specific goals and face significant challenges.[15] This model can also be applied in efforts to achieve the SDGs. In practice, this innovative approach has been employed in numerous initiatives and projects with disparate scopes at the national and international levels. Those projects and initiatives have focused on major issues in the health, energy, water, food and environment sectors, all of which are important sectors addressed in SDGs 2, 3, 6, 7, 13 and 17.

The mission-oriented innovation approach is particularly important in the Arab region because it allows Arab Governments to play a pivotal role in the innovation process, given that they play a prominent role in coordinating the stages of innovation processes and in directing research and development. This approach also addresses important development issues at the global and regional levels, such as climate change, water, energy and food security, and education, and it meets the needs of Arab countries in urgent social areas, such as energy, health, the environment, education and employment, especially in Arab countries affected by crisis and conflict. Moreover, the mission-oriented innovation approach allows researchers and innovators in the Arab region to collaborate and participate in international innovation programmes.

C. SOCIAL INNOVATION

Social innovation is a new approach, both in terms of its means and targets, which facilitates meeting social needs, engaging and assisting beneficiaries, and transforming social relationships by improving beneficiaries' access to power and resources.[16] Social innovation is not necessarily linked to technology, but it is also not separated from it. It is cross-sectoral innovation that can occur in any sector, and often involves several sectors. Most social innovation projects are driven by entrepreneurial initiatives launched by social entrepreneurs.

In the past 10 years, activities to stimulate social innovation have begun spreading in the Arab region, especially since the international development community began directing its attention, plans and funding to social entrepreneurs in the region.[17] In various Arab countries, international and regional networks and organizations have deployed various mechanisms and tools, such as innovation labs and world cafes, to disseminate a culture of social work and an entrepreneurial mindset.

Social innovation benefits from digital platforms that allow real-time access to new methods and ideas, making the digital environment the main driver of social innovation.[18] It will therefore be difficult for policymakers to influence these innovations through public innovation policies. They will have to use digital and network mechanisms to raise awareness of and disseminate social innovation. Social innovations vary because they depend on the local cultural and social context. Consequently, it is difficult for policymakers to take advantage of and scale up ready-made innovations. Therefore, it will be interesting to hold contests to devise innovative solutions to social problems, and to provide material and logistical support to startups to help them expand their businesses.

D. INCLUSIVE INNOVATION

Inclusive innovation, by its most widespread definition, is any innovation that leads to high-quality goods and services at an affordable cost, thus providing employment opportunities for excluded populations

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[15] Mazzucato and Penna, 2016.

[16] The Theoretical, Empirical and Policy Foundations for Building Social Innovation in Europe, 2014.

[17] Chahine, 2017.

[18] UNCTAD, 2017.

at the base of the population pyramid.[19] Inclusive innovation initiatives aim to improve the living conditions of low-income populations by better meeting their needs. Inclusive innovation has proliferated in recent years because products and services were often targeted at the wealthiest segments of society, without focusing on low-income consumers.[20] The innovative mindset of companies in developing countries was also geared towards innovation for global competition, which is incompatible with the philosophy of inclusive innovation.

This innovation is economical and inclusive by nature, with significant potential in contributing to achieving the SDGs. The scope of beneficiaries is wide and includes the most marginalized groups. Inclusive innovation also covers important development sectors, such as health, education, energy and food, and is centred on improving livelihoods and social integration.

According to the literature, policies supporting inclusive innovation are based on the following four pillars:[21] expanding the scope of innovation to include key sectors for marginalized groups, such as health, education and energy; focusing on low-income groups; increasing the size of innovation to benefit the greatest number of people in need; and ensuring the proper use of innovation to achieve the desired impact.

E. GRASSROOTS INNOVATION MOVEMENTS

Grassroots innovation movements are a type of collective inclusive innovation, rooted in reactions to social grievances, environmental problems, and innovative technological solutions that have not taken social dimensions into account.[22] This innovation approach draws on social movements and networks of social activists, academics and actors who use alternative forms of innovation, and seek to harness technology and generate knowledge relevant to them.[23] The drivers of grassroots innovation movements intersect across the following three dimensions: the technical dimension reflected in the economical pattern of innovation; the social dimension reflected in social innovation, and the environmental dimension reflected in innovation for sustainable development.[24]

The impact of grassroots innovation is expected to be positive in meeting consumer needs, enhancing productivity and sustainability, reducing poverty and achieving inclusion.[25] Along with inclusive innovation, grassroots innovation movements can also contribute to achieving the all the SDGs, especially the first 10 Goals.

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[19]   OECD, 2015b.

[20]   Foster and Heeks, 2015.

[21]   Foster and Heeks, 2016, pp. 4-6.

[22]   Smith, Fressoli, and Thomas, 2014.

[23]   Fressoli and others, 2014.

[24]   Pansera and Sarkar, 2016.

[25]   Ibid.

The question is whether the Arab region is willing to accept the potential spread of grassroots innovation movements, and how to harness it for the benefit of knowledge, social and environmental development. To support grassroots innovation initiatives in Arab societies, the Centre For Environment and Development for the Arab Region and Europe (CEDARE) was established with the support of the European Union-funded Switch-med programme.[26] This pilot initiative in the Arab region has resulted in a manual on grassroots innovation initiatives in the field of sustainable production and consumption.[27]

F. OPEN AND COLLABORATIVE INNOVATION

Open and collaborative innovation began spreading in the early 2000s, because the linear innovation approach had limited the dissemination of knowledge and innovation to specific companies or universities, which weakened the link between research and development and impeded the spread of innovation in societies. Several factors have helped in the move towards an open and collaborative innovation model,[28] notably the growing number of 'knowledge workers' and their growing skills in this area; the rise of risk capital that has challenged the concentration of innovation in closed companies; and the growing capacity of knowledge providers from outside closed companies.

Open innovation has resulted in a for-profit business sector comprising a variety of intermediary companies, which take the form of open digital platforms and attract the collective intelligence of innovators to market it later for their benefit or for the benefit of large companies seeking solutions and innovations. Open digital platforms are classified according to their various activities and interests:[29] research and development platforms such as Innocentive and IdeaConnection, design and marketing platforms such as CMNTY Corporation and CrowdSPRING, collective intelligence platforms, such as Luminogic, Ushahidi and Kaggle, platforms for open innovation software, such as Imaginatik, Napkin Lans and Venture Spirit, open innovation intermediary services, such as Big Data Group, Choardix and Data Station, and corporate initiatives such as Fiat Mio, Dell IdeaStorm and BMW Customer Innovation Lab.

G. REVERSE INNOVATION

Reverse innovation emerges first in developing countries before spreading to developed industrial countries. It revolves around developing inexpensive models of goods to meet the needs of developing countries, such as creating battery-powered medical devices and reassembling them into innovative and low-cost goods in developed countries. However, this approach is not sufficiently competitive, because it targets only the wealthiest populations in developing countries. Companies therefore resort to a reverse innovation approach that allows them to manufacture such products in developing countries and test them in those markets. Once successful, products are upgraded for marketing in developed countries.

The spread and development of reverse innovation in the Arab region could help reduce poverty, create new growth potentials, increase export earnings, improve balance of payments, promote foreign direct investment in all economic fields, encourage foreign direct investment in research and development, and create new jobs, especially for young people.

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[26] http://www.switchmed.eu/en/corners/civil-society.

[27] Regional Activity Centre for Sustainable Consumption and Production, 2015.

[28] Chesbrough, 2003.

[29] https://www.boardofinnovation.com/list-open-innovation-crowdsourcing-examples/.

Table 2 summarizes the characteristics of the above-mentioned innovation approaches, including the traditional linear model. It assesses the contribution of each approach to achieving the SDGs, and shows the success factors of using these approaches in the framework of innovation policies for sustainable development.

TABLE 2. SUMMARY OF INNOVATION APPROACHES AND THEIR CONTRIBUTION
TO THE ACHIEVEMENT OF THE SDGS

Innovation approach	Characteristics	Contribution to sustainable development	Success factors
Linear innovation	• Employs a simple and clear method; • Relies on research and development; • Strives for scientific precedence and industrial technological development; • Impacts economic growth and competition; • Adopts a top-down approach.	• This approach has great potential to contribute to sustainable development, because it is linked to economic diversification, economic growth, industrial development, and improved competition; • It contributes to achieving many SDGs, especially Goals 3, 4, 6, 7, 8, 9, 11, 13 and 17.	• Formulating a clear and effective national innovation policy; • Developing an effective and flexible national innovation system that helps develop teaching methods, activate scientific research, and improve legal and regulatory frameworks; • Enhancing interaction between scientific research institutions and the private sector.
Mission-oriented innovation	• Deals with major and intractable problems that pose national, regional or global challenges; • Adopts a participatory approach in defining trends and a centralized approach to implementation, with the Government playing a distinct and often dominant role in this process.	• This approach has great potential to contribute to sustainable development, because it addresses major issues, particularly in the health, energy, water, food, environment, and industrial and technological development sectors; • It contributes to achieving many SDGs, especially Goals 2, 3, 6, 7, 9, 13 and 17.	• Adopting a participatory approach in setting priorities and formulating tasks, including collaboration with the business sector; • Guiding research and development programmes in line with specific tasks; • Developing mechanisms to stimulate investment in the themes associated with specific tasks; • Benefiting from collaboration opportunities provided by international programmes.
Social innovation	• Adopts a transformative approach; • Begins from the grassroots through social entrepreneurship projects; • Relies on digital technology to reach marginalized groups; • Utilizes collective intelligence.	• This approach has a direct impact on sustainable development because it creates social change directly linked to social and environmental sustainable development; • It contributes to the achievement of many SDGs, especially Goals 1, 2, 3, 4, 5, 10 and 16.	• Facilitating the tasks of social entrepreneurs; • Providing legal frameworks for the registration of social companies; • The business sector accepts and cooperates with non-profit social work.

Innovation approach	Characteristics	Contribution to sustainable development	Success factors
Inclusive innovation	• Targets poor and marginalized groups; • Intersects with economical and grassroots innovation; • Relies on digital technology to reach marginalized groups.	• This approach has great potential to contribute to sustainable development because it extends innovation to the most marginalized groups in various sectors. It is also called 'innovation for the poor'; • It contributes to the achievement of many SDGs, especially Goals 1, 2, 3, 4, 5, 6, 7, 8, 9 and 10.	• Developing funding mechanisms to support inclusive innovation initiatives; • Removing regulatory barriers to the institutionalization of inclusive innovation projects, such as facilitating the registration of social companies.
Grassroots innovation movements	• Adopts an inclusive bottom-up approach; • Supports the expansion of the digital revolution; • Relies on civil society and volunteerism; • Promotes the environmental dimension.	• This approach has great potential to contribute to sustainable development through its linkages to the environmental and social dimensions; • It directly supports the circular economy; • It contributes to the achievement of all SDGs, especially Goals 1, 2, 3, 4, 5, 6, 7, 8, 9 and 10.	• Governments ability to take a holistic approach to movements and organizations, such as manufacturers and manufacturing laboratories, and to harness them for knowledge, social and environmental development; • Recognizing and supporting civil society.
Open and collaborative innovation	• Causes a fundamental shift in the concept of cooperation for innovation and collective intelligence; • Relies on the enabling and important role of digital technology.	• This approach has great potential to contribute to sustainable development given the promising role of open science and collective intelligence in finding solutions to many problems in health, education, agriculture and the environment; • It contributes to the achievement of many SDGs, especially Goals 3, 4, 6, 7, 9, 11, 13, 16 and 17.	• Accessing knowledge sources, including open science, open data, open software and open platforms; • Developing digital infrastructure.
Reverse innovation	• Causes a fundamental shift in innovation from the South to the North; • Intersects with frugal innovation and grassroots innovation.	• This approach has great potential to contribute to sustainable development because it attracts foreign investment; • It supports the national economy by attracting international research centres;	• Formulating a clear and serious national innovation policy; • Developing incentive mechanisms; • Establishing mechanisms to preserve the rights of innovators.

Innovation approach	Characteristics	Contribution to sustainable development	Success factors
		• It contributes to the achievement of many SDGs, especially Goals 1, 8 and 9, and may contribute to the achievement of Goals 3, 6, 7, 11, 13 and 17.	

Source: Compiled by ESCWA.

Each approach can contribute to some extent to development and to addressing the economic, social and environmental issues of sustainable development, especially those with transformative objectives. These innovative transformative approaches play a crucial role given the transformation requirements of the SDGs and weak capacity and resources in many Arab countries.

The choice of the best approach to address development issues depends on the nature of those issues, the environment, existing potential, and solutions adopted for similar issues. The choice of an appropriate innovation approach is itself an innovation process, and several innovative approaches can be relied upon and integrated according to the sequence of stages in addressing issues. It is important to identify innovative approaches that have proven successful based on success stories from developing countries similar to Arab countries. Decision makers should provide the necessary avenues for the success of different innovation approaches by including their requirements in national innovation policies, strategies and programmes.

Recommendations to decision makers and policymakers in the Arab region to stimulate innovation in all its forms:

In addition to traditional innovation approaches, particularly the linear innovation model, attention should be given to new approaches that have proved effective in achieving the SDGs. All innovation approaches and the adoption of hybrid models in implementation should be encouraged. Many innovation projects have been launched from grassroots bases and completed at design and research centres, or were launched by the national innovation system and have impacted the poor. Bridges between informal knowledge and practices and formal innovation processes need to be built, requiring the expansion of the national innovation system to accommodate more actors, infrastructure, enabling frameworks and legislation. This was confirmed by ESCWA in a 2017 study entitled *Innovation Policy for Inclusive Sustainable Development in the Arab Region*, which sets out a framework that includes some innovation approaches;

Setting national priorities for development in collaboration with stakeholders is a prerequisite for more enabling policies. Achieving the 2030 Agenda requires forging strong partnerships between all stakeholders, such as the public sector, academia, the private sector, non-governmental organizations and individuals;

Regulating transnational innovation requires the adoption of global innovation systems geared towards sustainability and transformative change. The necessary assistance can be obtained from several actors at the global level and from United Nations initiatives, including the United Nations Commission on Science and Technology for Development and the Technology Facilitation Mechanism. Greater networking between governmental and non-governmental actors and experts is needed to build capacity to adapt innovations to local contexts and cultures;

In the absence of reliable data in the Arab region, data collection capacity should be strengthened, especially those related to key indicators of social and economic performance, since absent or unreliable data lead to misleading policies and misallocation of resources. In this context, it is necessary to build the capacity of national statistical offices to collect data, maintain data independence and make data available on the Internet, and to obtain the support of United Nations agencies and other international institutions in collecting accurate, reliable and timely data and indicators;

Education is essential to building innovation capacity, but the education system in the region discourages innovation and entrepreneurship, including social work. Education policies and methods must be adjusted to stimulate analysis, constructive criticism and innovation, and the concepts of innovation and entrepreneurship must be incorporated into school and university curriculums to educate young people about the long-term benefits of innovation, particularly to resolve high unemployment;

The research and development system should be developed to encourage scientific research in universities, research centres and the private sector; incentives for scientific research and innovation should be implemented; national programmes linking academic researchers to the private sector should be developed; and special tax incentive policies should be formulated to promote scientific research and innovation in the private sector and in startups and small enterprises;

Government involvement in supporting innovations, particularly social and inclusive innovation projects, should be expanded through the involvement of ministries not directly responsible for innovation, such as the ministries of social affairs, agriculture, local administration, health and education;

Intermediary institutions and other means of communicating knowledge, such as digital platforms, should be supported to provide technical expertise to innovators in society, gather information on the needs of the poor to stimulate innovations targeting them, build bridges between grassroots innovation and official actors, and provide services for innovation;

The top-down approach is no longer sufficient for innovation. While the role of Governments remains central to the development of a national system of innovation that stimulates economic growth and productivity, a system aimed at transitioning towards sustainable development should also be developed.

III. EMERGING TECHNOLOGIES FOR THE SUSTAINABLE DEVELOPMENT GOALS

Over 100 new and emerging technologies are being deployed today, according to recent studies in OECD and European Union countries. They are expected to spread soon and bring about radical changes in various social, economic and environmental fields.[30] These technologies are divided into the following four groups:

(a) Digital technology and the resulting innovations that have been integrated with other technologies to produce new technologies such as artificial intelligence, robotics, the Internet of Things and big data;

(b) Biotechnology is beginning to bear fruit in agricultural, medical and other fields, particularly in genetics which promises treatments for serious and deadly diseases such as cancer;

(c) Advanced materials technology, which has produced new sets of materials with amazing applications such as nanomaterials, biomaterials and functional materials;

(d) Energy and environment technologies that play a key role in achieving the SDGs related to energy, the environment and transport.

Most of those emerging technologies consist of several other technologies that enable and develop them within what is known as the phenomenon of technological convergence.

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[30] OECD, 2016b.

1. *Internet of Things*

The Internet of Things (IoT) provides many opportunities to improve human health and monitor health risks, by linking implanted sensors to health monitors and health-care systems.[31] It helps develop the concept of smart assets; in other words, physical objects capable of recording and communicating information about themselves and their surroundings.[32] Smart grids equipped with IoT and smart energy meters enable the connection of homes or workplaces to the power grid, help reduce energy consumption and utility operation costs, and reduce power outages and energy waste by providing real-time network status information.[33] IoT also promises to improve transport management and traffic safety. Sensors connected to vehicles and road infrastructure may become interconnected, thus generating information on traffic, the technical status of vehicles, and road conditions. IoT technology is expected to help develop smart cities and infrastructure, improve manufacturing and productivity processes, strengthen supply chain risk management, and reduce waste.[34] The localization of IoT technology requires digital infrastructure and capacity-building in technology, especially in the analysis of big data and in the field of artificial intelligence.

2. *Big data*

Big data analysis allows for increased productivity and inclusive growth by providing education opportunities to more people, improving employment opportunities, and contributing to citizens' wellbeing.[35] Through data-based governance, management efficiency in the public sector can be improved, and public confidence can be renewed through increased transparency and accountability.[36] The concept of open data allows many scientific data to be attached to large datasets, and enhances the concept of citizen science. Through the exchange of data in the health sector, access to health care is increased and diseases are easily detected before symptoms develop.

While big data offers many benefits for sustainable development, it also poses major challenges and requirements such as capacity-building in data analysis, developing employment policies to respond to the growing demand for data analysts, and amending educational curriculums by focusing on STEM skills. It also requires fast and widespread Internet access, enhanced computing and storage capacity, and establishing a legal and legislative system to ensure a smooth flow of data between countries, sectors and organizations.

Dependence on big data in development processes requires bridging the digital divide at the national level to avoid another gap between data holders and non-holders, and between those whose needs and requirements are taken into account in policymaking and those that are not, which may undermine social cohesion. Big data technology raises concerns about privacy, confidentiality and information security, because big data analysis allows for personal data analysis that may become accessible to a large number of actors. Consequently, laws and regulations are required to protect privacy and personal data.

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[31] Akyildiz and others, 2015.

[32] Ibid.

[33] OECD, 2015a.

[34] McKinsey and others, 2017.

[35] World Economic Forum, 2015.

[36] OECD, 2016.

3. *Artificial intelligence*

Artificial intelligence (AI) promises productivity gains, improved decision-making, and lower costs owing to its reliance on big data processing. It also contributes to addressing the challenges associated with the environment, transport and health, and to improving quality of life through its impact on all economic sectors.[37] AI ensures safety at work because machines minimize work accidents and result in the right decisions in dangerous situations. The use of AI technology is expected to spread throughout the service sector, and become a part of everyday life by 2030. AI helps improve the lifestyles of families through robots that provide physical and psychological service to older persons. AI will also be used in education, medicine, law, marketing and finance. In the health sector, surgical robots are increasingly being used, and medical diagnosis will evolve as a result of the analysis of big medical data.

Nonetheless, many decision makers fear the negative effects that may accompany the development of artificial intelligence, most importantly the negative impact on jobs. AI applications can replace an increasing number of administrative, cognitive and analytical functions. Automation, which applies to the routine aspects of jobs, makes no distinction between manual and intellectual tasks, and may affect nearly half of activities in the global economy. However, studies seem sceptical about this negative effect, because estimates show that less than 5 per cent of job can be fully automated.[38] Another negative effect of artificial intelligence is that it may make a mistake that causes serious damage, such as a misdiagnosis. Its decisions may be rejected or misunderstood, raising questions about legal liability and how it is divided between an AI system and the people who created and programmed it. These problems will have significant consequences for insurance markets and intellectual property laws.

The localization of AI requires policies on its ethical use, and the provision of reliable networks for transport, energy and communications, including the Internet of Things. The demand for new skills in the development of artificial intelligence systems is expected to grow, but creative or tacit knowledge that is hard to encrypt and skills that require social interaction will remain in human hands in the coming decades. Curriculums should be developed to equip young people with the skills to work in an AI-enhanced environment.

4. *Blockchain technology*

Blockchain technology provides innovative financial transaction solutions, because it allows free cross-border money transfers and facilitates equitable crowdfunding. This technology helps create reliable and transparent records of any kind of data, including asset ownership, leading to improved public sector performance by increasing transparency, preventing corruption and enhancing efficiency. This technology also allows individuals and organizations to modify smart contracts, which are referred to in the language of record-chain technology as 'programmable money'.[39]

Given the open and decentralized nature of this technology, it is feared that its negative impact will surpass the impact of the Internet in producing hidden transactions. As a result of this negative impact, Governments will face several challenges related to the issues of tax evasion, money laundering, terrorist financing, and drug and arms trafficking.

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[37] OECD, 2017a.

[38] McKinsey and others, 2017.

[39] Bheemaiah, 2015.

While this technology and its applications are used on the Internet, their local deployment requires access to the digital economy, the development of relevant national policies, the provision of infrastructure, and capacity-building.

5. *Additive manufacturing*

Additive manufacturing technology is also known as 3D Printing. Additive manufacturing includes several technologies and processes based on computer-aided design software. 3D printing helps stimulate innovation in the health, biotechnology and medicine sectors, including dentistry and prosthetic implants. 3D printing also has an environmental dimension because it reduces the volume of waste from manufacturing processes, and reduces the steps needed to manufacture, transport, assemble and distribute parts thus reducing material waste compared with conventional manufacturing methods.[40] [41] 3D printing is expected to make a qualitative leap in economic and social development, similar to the impact of mobile phones in poor countries, and lead to the establishment of printing startups with small capitals that increase as production increases.[42]

Nonetheless, this technology also poses challenges, most notably the chaos that may affect production control, consumer laws, trade barriers, patents, taxes and other government regulations. Three-dimensional printing can lead to the proliferation of illegal copies of jewellery and artwork, the illegal manufacture of weapons, and the random manufacture of human organs. The localization of this technology requires capacity-building and the provision of digital design supplies and tools.

B. TECHNOLOGY FORESIGHT FOR THE ADOPTION OF EMERGING TECHNOLOGIES IN THE ARAB REGION

The philosophy of foresight assumes that the future can be influenced by the development of policies and procedures to slow, accelerate or change certain trends. Foresight provides decision makers with many benefits, not least a strategic position vis-a-vis the future and the possibility of influencing it. Today, foresight has become an urgent need in institutions and countries facing developmental and strategic challenges. It is no longer confined to developed countries, but is also being adopted in many developing countries. Effective technology foresight depends on the generation and management of information in the following three stages: collecting data; analysing data and formulating different future scenarios; and developing strategic options for action.

The United Nations has identified foresight as one of the approaches that can contribute to the achievement of the SDGs, in particular Goal 16 on governance.[43] Strategic and technological foresight can support developing countries in their pursuit of the SDGs in the following four key areas:[44]

(a) Aligning the development visions of decision makers with the SDGs using forward-looking tools;

(b) Promoting proactive governance and strategic management of some emergency phenomena and crises that may hinder the implementation of the SDGs;

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[40] Ibid.

[41] OECD, 2017b.

[42] Ibid.

[43] Tesh, 2016.

[44] United Nations Development Programme, Global Centre for Public Service Excellence (UNDP-GCPSE), 2015.

(c) Supporting flexible policy planning, particularly for sustainable development, while taking into account the element of surprise to improve responses to different circumstances;

(d) Stimulating innovation in public policies and services given its importance in achieving sustainable development. Foresight can be coupled with all forms of innovation and offers new innovation opportunities.

C. RECOMMENDATIONS ON ADOPTING NEW TECHNOLOGIES IN THE ARAB REGION

Adopting new technologies requires policy development and measures to clarify the role of technology in achieving the SDGs. The following are proposals to help invest technology in national strategies and plans:

(a) Encourage the active participation of Governments, researchers, economists, experts, private sector institutions, and all stakeholders in addressing sustainable development issues and the role of technology in them, and conduct sectoral studies at the national, regional and global levels to identify opportunities and challenges related to accelerated technological change, especially in artificial intelligence, robotics and automation;

(b) Promote the disciplines of science, technology, engineering and mathematics, which form a recognized strategic basis for dealing with the coming industrial revolution. Public policies to stimulate these disciplines include:[45]

- Building the educational capacity of teachers in honing technical skills such as mathematics and informatics among school students;

- Promoting vocational training and education using new educational platforms;

- Establishing university institutions that focus on interdisciplinary programmes and promote entrepreneurship and innovation;

(c) Commit to the principle of technology facilitation at all levels and in all areas by providing an enabling environment for technology transfer and for the exchange and dissemination of knowledge on localization; improve market access and networking within and between sectors; and invest in infrastructure, while taking into account vulnerable and marginalized groups;

(d) Adopt global standards, including technology licensing rules, so to provide them in advance to countries;

(e) Benefit from United Nations technology linkages and mechanisms, such as the Technology Facilitation Mechanism, to continue mobilizing the scientific and technological communities, the private sector and civil society;

(f) Promote women's participation in science and technology by encouraging them to specialize in science, technology, engineering and mathematics, and encourage their participation in the scientific and technological communities in the public and private sectors and in scientific and technological research programmes. Global programmes to encourage women's participation have been launched, such as the L'Oréal-UNESCO For Women in Science Awards;[46]

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[45] Abdul Wahed, 2017.

[46] http://www.unesco.org/new/en/natural-sciences/priority-areas/gender-and-science/for-women-in-science-programme/; https://en.wikipedia.org/wiki/L%27Or%C3%A9al-UNESCO_For_Women_in_Science_Awards.

(g) Encourage young people to participate in scientific and technological development, because all countries worldwide will witness changes in labour markets and growing demand for scientific and technological disciplines that contribute to technology investment and the development of applications adapted to sustainable development needs;

(h) Disseminate digital technology given its importance in providing an enabling environment for new technologies. Disseminating digital technology and bridging digital gaps in the short and medium term requires the following:

- Promoting competition by regulating the digital sector and encouraging public-private partnerships to make the Internet available to all;

- Providing infrastructure for urban and rural broadband connectivity;

- Developing a digital entrepreneurship system, especially for women and young people, and supporting new digital business initiatives, such as business incubators, startups, funding and training agencies, and non-governmental initiatives;

- Supporting digital transformation processes within traditional and public sector enterprises;

- Conducting a digital transformation of the health-care system by providing Internet and smart phone services, and shifting technological infrastructure towards cloud services;

(i) Adopt a foresight approach in science and technology as an effective tool for assisting policymakers in coping with rapid technological and social changes, and provide the following requirements for its success:

- Integrating foresight into the institutional structures of the State by forming a permanent, multidisciplinary advisory body, comprising representatives of the private sector, dealing with foresight issues;

- Mainstreaming a culture of foresight and cementing it in the minds of decision makers in the legislative and executive branches to gain institutional support;

- Providing political support at all stages of the foresight process and in subsequent monitoring of and interaction with developments;

- Involving stakeholders, experts, academics and business people in all foresight processes.

IV. RECOMMENDATIONS FOR RELIANCE ON SCIENCE, TECHNOLOGY AND INNOVATION FOR SUSTAINABLE DEVELOPMENT

The present chapter reviews the state of science, technology and innovation in Arab countries, and makes recommendations to Arab countries on improving investment in this field in line with their national priorities and the progress they aspire to make in relying on technology and innovation to achieve the SDGs.

A. SCIENCE, TECHNOLOGY AND INNOVATION IN ARAB COUNTRIES

Given the important role of STI in achieving any national vision or development plan, ensuring social welfare and developing the competitiveness of the economy, it is useful to analyse the status of STI in the development plans of Arab countries based on international indicators.

1. *Status of Arab countries according to global indicators*

Arab countries vary in their institutional and human capacity, their level of development, and their reliance on technology. To illustrate the status of Arab countries with regard to technology, innovation and

sustainable development, it is necessary to resort to global indicators, namely the Global Competitiveness Index, the Global Innovation Index and the Human Development Index (table 3).

TABLE 3. STATUS OF INNOVATION, COMPETITIVENESS AND HUMAN DEVELOPMENT IN ARAB COUNTRIES ACCORDING TO GLOBAL INDICATORS

Country	Global Innovation Index ranking[a] (2019)	Overall Global Innovation Index rating[a]	Global Competitiveness Index ranking[b]	Overall Global Competitiveness Index rating[b]	Human Development Index ranking[c]	Overall Human Development Index rating[c]
Jordan	86	29.61	73	59.3	95	0.735
United Arab Emirates	36	42.17	27	73.4	34	
Bahrain	78	31.10	50	63.6	43	0.846
Tunisia	70	32.83	87	55.6	95	0.735
Algeria	113	23.98	92	53.8	85	0.754
Syrian Arab Republic					155	0.536
Sudan					167	0.502
Iraq					120	0.685
Oman	80	30.98	47	64.4	48	0.821
State of Palestine					119	
Qatar	65	33.86	30	71	37	0.856
Kuwait	60	34.55	54	62.1	56	0.803
Lebanon	88	28.54	80	57.7	80	0.757
Libya					108	0.706
Egypt	92	27.47	94	53.6	115	0.696
Morocco	74	31.63	75	58.5	123	0.667
Saudi Arabia	68	32.93	39	67.5	39	0.853
Mauritania			131	40.8	159	
Yemen	129	14.49	139	36.4	178	0.452
Average rating		30.31		58.4		0.713

Source: Compiled by ESCWA.

[a] https://www.wipo.int/edocs/pubdocs/en/wipo_pub_gii_2019.pdf.
[b] http://reports.weforum.org/global-competitiveness-report-2018/the-global-competitiveness-report-2018/.
[c] http://hdr.undp.org/en/content/human-development-indices-indicators-2018-statistical-update.

2. *Status of science, technology and innovation in development plans*

Several Arab development visions have highlighted the role of STI in development, with some focusing on the importance of advancing education and human capacity to develop entrepreneurship (Jordan, Kuwait and State of Palestine). Many Arab development visions stress the role of STI in economic development and building a knowledge society (Libya, Oman, Qatar, Saudi Arabia, Syrian Arab Republic and United Arab Emirates). Some also emphasize the importance of scientific research (Egypt, Oman, Qatar and Saudi Arabia), and link STI to sustainable development (Egypt and Morocco).

3. *Voluntary national reviews in Arab development plans*

Voluntary national reviews aim to track progress in implementing the 2030 Agenda and its Goals and targets in all developed and developing countries. Although Arab States have indicated their willingness to submit voluntary national reviews to monitor the implementation of the SDGs, and while United Nations

agencies and other international and regional structures are helping in this area, Arab countries have been slow and irregular in submitting such reviews since 2016 (table 4).

TABLE 4. SUBMISSION OF VOLUNTARY NATIONAL REVIEWS IN THE ARAB REGION

Country	2016	2017	2018	2019
Jordan		✓		✓
United Arab Emirates			✓	✓
Bahrain			✓	✓
Tunisia				✓
Algeria				✓
Sudan			✓	✓
Iraq				✓
Oman				✓
State of Palestine			✓	✓
Qatar		✓		✓
Kuwait				✓
Lebanon			✓	✓
Egypt	✓			✓
Morocco	✓			✓
Saudi Arabia			✓	✓
Mauritania				✓

Source: www.unescwa.org/events/arab-forum-sustainable-development-2019.

Note: Countries that submitted voluntary national reviews are indicated by dark blue cells.

The Syrian Arab Republic recently issued its first national review on sustainable development, which aims to assess progress in achieving the Millennium Development Goals between 2000 and 2010, and to analyse impacts between 2011 and 2015. The Syrian Arab Republic intends to use the findings, priorities and indicators contained in the review to prepare post-crisis development plans.[47]

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[47] http://www.arabdevelopmentportal.com/ar/publication/first-national-report-sustainable-.development-goals-sdgs.

4. *Integrating science, technology and innovation in sustainable development*

Following global discussions on integrating STI in national development plans, three stages were agreed upon: establishment, adaptation and integration. These stages are based on 10 key elements divided into three categories, namely methodologies, policy content and implementation (table 5).

TABLE 5. KEY ELEMENTS OF THE STAGES OF INTEGRATING SCIENCE, TECHNOLOGY AND INNOVATION IN DEVELOPMENT PLANS

Methodologies	• Assessing STI needs and gaps; • Conducting foresight analysis; • Ensuring detailed understanding of the SDGs and adopting integrated assessment tools that help to strengthen inter-sectoral linkages.
Policy content	• Formulating an integrated set of STI policies and incorporating enabling factors therein, such as a legislative environment, intellectual property rights, and investment policies; • Examining the socioeconomic impact of rapid changes caused by emerging technology; • Linking STI to national development challenges and development strategies.
Implementation	• Building the STI capacity of individuals and institutions; • Strengthening coordination between various government agencies and encouraging them to coordinate with the private sector, the scientific community, and all stakeholders; • Evaluating progress; • Identifying suitable funding sources.

Source: United Nations Department of Economic and Social Affairs, and others, 2018.

(a) Establishment phase: STI policies are developed in this stage, while considering appropriate conditions and enabling factors. Most countries have medium- or long-term national STI policies or strategies that are overseen by the Ministry of Science and Technology, the Ministry of Industry or the Ministry of Economy. These strategies define the legal and administrative frameworks for academic research, intellectual property, the enterprise ecosystem, and technology commercialization. Most countries also have bodies responsible for coordinating between ministries and stakeholders in the Office of the President, the Cabinet Office or the national development commission, supported by the ministry responsible for the national science and technology strategy;

(b) Adaptation phase: Countries' performance varies in anticipating and adapting to rapid technological changes. This stage involves addressing potential concerns, such as automation and unemployment, cybersecurity, and bioethics. It also provides opportunities for the development of solid regulatory frameworks, as in Rwanda on drones, in Serbia on the Fourth Industrial Revolution; and the human-centred vision of Japanese society (Society 5.0 of Japan). Adapting to emerging technology requires increased preparedness and awareness in society;

(c) Integration phase: Most countries have yet to fully integrate STI in national sustainable development visions. This integration depends on the following three main factors:

- Influence of the cultural context, the political and administrative leadership, and accession to regional or other cooperation bodies requiring adherence to common policy standards;

- Level of awareness, willingness and ability to harness science and technology to achieve national priorities. In countries that have not yet reached a high level of maturity in STI

institutions, other factors influence integration, such as early successes in science and technology;

- The breadth and depth of links between policymakers and STI stakeholders, including local research institutes and international stakeholders.

Since Arab countries are still novices in harnessing STI for sustainable development, common challenges revolve around generating awareness, momentum and political will, and incorporating integrated STI approaches in planning for the SDGs. Recommendations to various stakeholders, including Governments, the private sector, academia and non-governmental organizations, should therefore be proposed, while considering disparities in benefits from innovation and technologies adopted in Arab countries.

B. Proposals and recommendations for operationalizing innovation policies to achieve the SDGs in Arab countries

The present chapter contains four sets of recommendations for Arab countries to rely on STI in national policies. Countries can choose the recommendations that suit their potential and expectations from using science and technology for sustainable economic, social and environmental development. Criteria have been identified for the four proposed sets (table 6).

Table 6. Criteria of proposed recommendations for integrating STI in national policies

Criteria for set 1	Criteria for set 2	Criteria for set 3	Criteria for set 4
- High-income countries; - Long-term national visions based on STI; - Relatively integrated STI system, i.e. supervisory and administrative laws and structures; - Good infrastructure for education, health and transport; - High rates of ICT use; - Decision makers show great interest in scientific research.	- Middle- or high-income countries; - Long-term national visions or at least development plans; - An integrated system of scientific research and innovation but with limited returns; - Good infrastructure for education, health and transport; - Above-average rates in ICT use; - Decision makers are interested in scientific research.	- Countries with middle or low income; - Four- or five- year development plans; - Non-integrated system of scientific research and innovation, i.e. a lack of laws, and supervisory and administrative structures; - Available infrastructure for education, health and transport; - Average rates of ICT use; - Decision makers show a formal interest in scientific research.	- Countries with low income, emerging from war, or in a state of war or instability; - Fragile economic fabric owing to political circumstances; - No scientific research and innovation system; - Weak infrastructure for education, health and transport; - Below-average rates in ICT use; - Decision makers show little interest in scientific research.

Source: Compiled by ESCWA.

The following are the proposed sets of recommendations:

1. *Set 1: Stimulate reliance on new technology in economic development*

Relying on new technology for economic development requires ready and robust research and development infrastructure. To improve technology-efficient human resources, policies must be developed to attract experts and build specialized human capacity in this field. Industrial policies should be developed while

taking into account emerging technological developments, and incentive tax policies that encourage private sector engagement in high-tech industries. In addition the role of civil society should be strengthened given its impact on policymaking. Moreover, financial resources should be allocated to encourage national institutions to invest in technology and contribute to the advancement of science.

To attract foreign investment, incentives must be provided to attract the world's leading technology companies and build good relationships with them. This is a prerequisite for success, but it is not easy in developing countries, including Arab countries. Studies show, for example, that most STI parks in Latin America need to expand, attract more knowledge holders or high-tech companies, and encourage technological collaboration between national and foreign institutions. This also applies to the situation in Arab countries.

While all innovation approaches are important for achieving this set of recommendations, linear and mission-oriented innovation may be key to shifting towards a technological knowledge society.

2. *Set 2: Develop incentive financing measures to support the national innovation system and entrepreneurship*

Funding measures should be taken to stimulate the creation of more innovative companies. Providing capital and regulating financial markets helps spread new technology and supports entrepreneurship, given that innovation requires significant financial investments. The unsecured and risky nature of innovation makes it more difficult to mobilize resources. Lack of access to finance by companies is a major barrier to innovation in all countries. Tax incentives, venture capital promotion and investment funds are therefore needed to facilitate innovation financing.

STI parks are among the most frequently used tools to increase interaction between components of the innovation system, and to foster collaboration between enterprises, universities and research centres. These parks need to be supported and funded because they reflect the desire of countries to support technological innovation so as to increase competitiveness and create more jobs.

Open and collaborative innovation is a key approach to innovation that helps developing countries to become modern technology owners. This kind of innovation requires harnessing all collaborative methods, digital technology and collective intelligence to build partnerships in the innovative process. Linear, mission-oriented and social innovation can also help achieve this set of recommendations.

3. *Set 3: Support the establishment of a national innovation system and stimulate grassroots innovation approaches*

The components of the national innovation system should be supported through the development of ICT infrastructure that helps in moving towards a knowledge society. Balanced intellectual property systems should also be developed, and tax, investment and competition policies should be improved to encourage the private sector to develop innovative technological solutions. Governance mechanisms need to be put in place to guide national intelligent transport systems and stakeholder coordination. It is essential to align STI policies with the SDGs, expand the scope of relevant actors, and focus on human and economic institution-building in this field.

Strengthening the innovative capacity of economic institutions requires supporting the establishment of new innovative enterprises through the use of accelerators, incubators, training centres, science and technology parks, technology dissemination, and capacity-building to increase national productivity.

Measures and actions should also be taken to build strong relationships between State actors, industry and research organizations at the national and international levels. Academia should be linked to industry through programme funding, the establishment of technology transfer offices, and incentives for staff transfers between the industry and university sectors.

Grassroots, social, inclusive and reverse innovation approaches are key approaches that help devise technological solutions that impact social, economic and environmental development. Other innovation approaches can be adopted in the implementation of this set of recommendations, namely linear innovation, mission-oriented innovation, and collaborative and open innovation if the components for innovation, particularly a suitable national innovation system, are available.

4. *Set 4: Establish specialized institutions and provide technological infrastructure to stimulate grassroots innovation*

In countries targeted by this set of recommendations, the economic and social climate is affected by unstable political conditions. It is therefore necessary to remove political constraints, restore peace and stability, and establish STI institutions or support existing institutions to achieve the SDGs based on STI strategies. Intensive education and training should also be provided to all so as to build capacity for innovation and technology use. An enabling environment must be created for public and private investment in human capital, technological learning and the necessary infrastructure, such as electricity, communications and transport. Digital skills need to be enhanced through universal access to high-quality Internet and mobile broadband services. Innovative institutions, such as incubators and technology parks, also need to be established.

As a result of political and social instability, widespread poverty and the weakness of the national research and development system, inclusive, frugal and grassroots innovations may arise in countries targeted by these recommendations. Mechanisms must therefore be put in place to mainstream these innovative approaches and maximize their economic benefits.

Conclusion

The present report explores the differences between various innovation approaches and how they can be harnessed and integrated into national plans and strategies to maximize their benefits towards achieving the SDGs. This summary presents the transformations required to develop a conceptual framework for development in Arab countries. Moreover, it recommends a set of actions while considering different national contexts in the Arab region to operationalize innovation policies to achieve SDGs.

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The present study examines the importance of new approaches to innovation and modern technologies in development policies for achieving the Sustainable Development Goals (SDGs). It reviews the general concept of innovation and its impact on the wellbeing of peoples, after shifting from a specific scientific definition to a more flexible concept that covers a wide range of activities, from discovery to the practical application of new knowledge. New approaches to innovation include linear approach, mission-oriented innovation, social innovation, inclusive innovation, grassroot innovation, open and collaborative innovation, and reverse innovation. The study includes an evaluation of the contribution of each of these approaches to achieving the SDGs in the Arab region, and an evaluation of the success factors of each approach when used in innovation policies.

The study examines the link between innovation and technology, in view of the Fourth Industrial Revolution led by four technology groups: materials technology, digital technology, biological technology, energy technology and the environment. It analyses the impact of these groups on the social, economic and environmental aspects of life, and reviews some of the most promising technologies for the Arab region, such as artificial intelligence, the Internet of Things and robots. The study also presents four groups of recommendations addressed to Arab countries to integrate science, technology and innovation in their national plans to achieve the 2030 Agenda for Sustainable Development, in line with their science and technology capacity and expectations for sustainable economic, social and environmental development.