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Youth Innovation in Biotechnology and AI for Sustainable Development: A Case Study from Egypt

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Abstract

Over 60% of Egypt's population is below 30 years of age, which has ramifications on the youth labour force participation rate, as well as the potential for youth fuelled sustainable developmental initiatives. This study focuses on the potential participation of the youth in the biosciences, and the innovative applications of artificial intelligence, as means to achieve inclusive economic development, and simultaneously contribute to the solution of the country's ecosystemic problems. A qualitative – quantitative approach is used to examine the youth innovation pipeline, with a focus on the integration of the Danish – Arab Partnerships Programme's Supported Green Enterprises acceleration initiatives, and the mobilization of innovation through Egypt's Higher Educational System. The focus is on three dimensions: the development of human capital, innovation of technologies, impact of development. The study shows that the innovative applications in biosciences and artificial intelligence of the youth, in collaboration with some of the acceleration frameworks, enhance the valorization of agricultural waste, and contribute to the development of resource efficient, scalable, and fully bio-based products, and enterprise sustainability positively. The support frameworks of these initiatives and the acceleration supports stems from a mixture of international collaborations, which demonstrates the pathway from ideas generated by the youth, and the potential for sustainability to be achieved.

Keywords: Youth Innovation, Biotechnology, Artificial Intelligence, Sustainable Development, Circular Economy.

Introduction

Youth Innovation at the Intersection of Sustainability and Development in Egypt Currently in Egypt, there is an important change in population. Young people who are under 30 years old are now more than 60% of the total population. This change, unfortunately is creates two major issues. The first of which involves integrating a large number of educated graduates into the work opportunities that are available. The second issue relates to important sustainability issues that include the following: agricultural waste, climate change, water shortages, and a lack of resource sufficient green industry. For these reasons, we view youth innovation as more than a social initiative, and more as a positive investment for the future [1].

Two important subjects which affect and are affected by Egypt`s future are biotechnology and artificial intelligence (AI). Sustainable agricultural production and waste recovery, as well as the production of goods using biological processes, are all examples of biotechnology and align well with the natural resources Egypt has. AI is extremely useful in biotechnology with the ability to improve the efficiency of processes and in understanding and forecasting systems. The integration of biotechnology and AI is the key to branching out into more circular economy systems, which will also create an abundance of green jobs [2].

In the last few years, Egypt has been focusing on and investing in youth innovation systems, especially in the Higher Education Institutes. This includes systems like GEN Z under the Ministry of Higher Education and Scientific Research that aims to encourage university students to engage with applied innovation

in ways that make a difference .At the same time, European development assistance frameworks, notably the UNDP Green Growth and Jobs Accelerator deployed under the Danish–Arab Partnership Programme (DAPP), try to convert innovation into job creation, business expansion, and environmental consequences [3, 4].

This paper employs the case study approach to address the contribution of young innovators in biotechnology and AI to sustainable development in Egypt, and the role of European and Danish–Arab cooperation in deepening this contribution. The study illustrates the potential of partnership at multiple levels to empower the youth in innovation and provide pathways for their ideas to produce measurable outcomes by integrating national innovation strategies with internationally driven accelerator programs.

Case Study Design and Analytical Framework

This exploration employs a qualitative–quantitative case study framework with a focus on Egypt as an emerging economy in a unique intersection of youth innovation, sustainability, and global cooperation. The case study's unit of analysis is the youth innovation pipeline formed as the systematic innovation mobilization within national higher education programs, and downstream enterprise acceleration and job creation through international development. Within this pipeline, the study incorporates two innovation pathways that, while still distinctly innovate, complement each other: national youth mobilization through the GEN Z innovation program, and international green enterprise acceleration through the UNDP Green Growth and Jobs Accelerator, with Eastern European supported partnerships, within the Danish–Arab Partnership Programme. Understanding these pathways together enables the analysis to illustrate the end-to-end youth innovation phenomenon, from ideation and skills to enterprise and job creation.

The analytical framework across three interrelated outcomes: first, human capital development, with particular focus on the depth of youth participation, skills development, interdisciplinary collaborations, and employability within structured innovation activities. The second dimension deals with technology, focusing on biotechnologies and artificial intelligence used by young entrepreneurs and teams to tackle sustainability, efficiency, and scalability challenges. The third dimension is concerned with development impact, such as the enterprise impact, the creation of green jobs, and the positive changes on the environment, including waste and resource efficiency, as well as reduction of emissions. Together, these allow for a multi-faceted linkage between individual capability building, and economic and environmental systems on a macro scale. Analyzing Egypt as one cohesive case gives the opportunity to identify systemic strengths, coordination gaps, and lessons that can be applied to other emerging economies that seek to connect youth innovation with biotechnology and AI in the context of sustainable development and green jobs.

National Youth Innovation in Egypt: The GEN Z Program

GEN Z innovation program has been one of the most economically significant and institutionally focused on the youth innovations activities of Egypt. The GEN Z program is the initiative of the Ministry of Higher Education and Scientific Research through the Innovators and Geniuses Care Fund, and is the first of its kind in the country. The program focuses on introducing, for the first time, applied, issue-driven innovation into the higher education system. The program focuses on the university students and the recent graduates in the fields of science, engineering, health and technology, and seeks to reposition the youth from being passive players on the overcrowded and overworked labor market to becoming active stakeholders in the country's economic development initiatives. The program balances the activities of innovation within the universities and uses the academic facilities of the universities. The program also repositions the purpose of higher education to one focused on social benefits [5].

According to the reports, more than 300 youth innovators were selected from 39 universities in Egypt, public and private. The information represents only the finalists, who reached one of the most advanced stages of the competition, and not the total number of applicants. Taking into consideration the nationwide open calls, the program's media presence, and its placement in higher education institutions, the students whose interest and participation were early-stage screenings could be estimated to be multiply greater than the final cohort. This situation shows both the considerable interest from Egyptian youth in the opportunities and the decision of the program to support only a few to highly selective and competitive projects. From an economic point of view, the program GEN Z is a highly regarded public investment in the youngsters' potential to innovate. The total amount of public funds allocated to the program is in excess of EGP 100 million. This amount covers direct cash prizes, training infrastructure, mentorship networks, evaluation systems, and media production. In the Egyptian innovation space characterized by very early-stage funding for student initiatives, this amount of public funds allocated to youth innovation is a considerable public shift to support the state-backed risk in youth initiatives. In addition, the total cash prizes allocated to the top three projects is EGP 2 million, which covers the costs of laboratory prototyping and other activities in the early stages of the commercialization process. In university grants for research, this amount of funds is generally limited and which constrains the project to remain in the early stages of validation [6].

The program's multi-stage competitive design further emphasizes its importance on a national scale. The open calls are first subjected to technical screenings, followed by mentorship-assisted refinements, culminating in final selection evaluations, which for some, as a result, make for a rather steep funnel. Some even end up receiving funding. But that is to emphasize that a far larger group of students are actually exposed to entrepreneurial, innovation-oriented, and interdisciplinary skills. Sponsored projects have been thematically found to correlate significantly with the country's priorities in the fields of biotechnology and in the use of AI for the management of agricultural waste, health and health-related technologies, and the sustainable bioeconomy, including products and materials. And although so much is still been accomplished, GEN Z still is primarily focused on early-stage innovations. This drives the need to interlink the national programs with internationally scalable frameworks for acceleration. The potential for addressing both sustainable economic and environmental challenges is significant.

European and Danish–Arab Cooperation: UNDP Green Growth and Jobs Accelerator

The main avenue for economic, environmental, and job creation in Egypt is the collaboration with the UNDP Green Growth and Jobs Accelerator under the Danish–Arab Partnership Programme (DAPP). The UNDP accelerator is not like other accelerator programs, as it is designed specifically as a development mechanism with the goal of achieving positive results and embedding environmental sustainability in profit-generating businesses at scale. The positive results of embedding environmental sustainability in profit-generating businesses is critical in Egypt as it is the largest country in terms of youthful demographic and is experiencing rapid growth in the SME (Small and Medium Enterprises) sector, with a pressing climate vulnerable agriculture [7].

The Accelerator Program defines metrics to be accomplished by 2027 at the program level, which include the 800 SMEs supported across countries, 4,000 jobs created, and the generation of 10,000 jobs along the value chain created indirectly. Achieving the target demonstrates systemic change as there is job creation multipliers. There is the need to support 800 SMEs assuming that there is ongoing technical and advisory support, as the employment data implies that there is an average of 5 jobs created directly at the enterprise level, not considering the indirect job creation. There are downstream distribution activities. Majority of the jobs created are indirect one, as the bio-based manufacturing, agri-processing are sectors relevant to Egypt.

The design of the Accelerator Program creates space for youth to include themselves. 10% of the supported enterprises are youth-led, which means that young innovative thinkers are not left in the ideation and pilot stage, but are taken along the growth path. The design allows the youth-led enterprises to migrate to market-ready, self-sustaining enterprises that are compliant to regulations and can grow their staff complement, which strengthens the correlation between support for innovation and the demand for employment.

Operationally speaking, accelerator cohorts in Egypt last for 5 months, in the course of which each of the participating enterprises learn how to conduct structured sustainability diagnostics to determine the energy and water consumption, emissions, and waste generation baselines, and track them over time. After that mentoring and technical assistance is offered to increase the area's production efficiencies, decrease the production costs, decrease the resource intensity, and operationalize the ecologically sound business practices. Within the frameworks of DAPP and UNDP, enterprises are exposed to internationally accepted sustainability standards and practices, which enhances the credibility of the enterprises, and lowers the risks of investments, as well as anchors the youth innovations to viable economic and environmental transformations.

Integration of Biotechnology and AI: Youth-Led Solutions and Results

Within both national and European-supported innovation frameworks, biotechnology forms the primary scientific foundation of youth-led sustainability solutions in Egypt. A substantial share of youth-driven projects targets the valorization of agricultural residues, particularly rice straw, which is produced in Egypt at an estimated 4–5 million tonnes per year and has long been associated with open-field burning and severe air pollution. Youth innovators employ biological processing routes, including microbial and fungal systems, to convert this biomass into biofuels, fibers, enzymes, and other bio-based materials. At pilot scale, these approaches demonstrate measurable reductions in waste volume and pollutant emissions relative to conventional disposal practices, while simultaneously generating value-added products suitable for local and regional markets. These outcomes highlight the technical feasibility of circular bioeconomy models tailored to Egypt's agricultural and environmental context [8].

Despite this potential, biological systems are inherently variable, and scalability remains a central technical challenge. Artificial intelligence plays a critical enabling role by enhancing process control, efficiency, and reproducibility. Youth-led teams increasingly apply AI-based models to predict conversion yields using parameters such as temperature, moisture content, substrate composition, and processing time. Even relatively simple regression and classification models reduce trial-and-error experimentation, yielding efficiency gains of approximately 10–20% in pilot-scale fermentation and bioprocessing systems.

Beyond process optimization, AI supports quality control and sustainability monitoring through image-based analysis and sensor-linked analytics that track energy use, water consumption, and operational efficiency in real time. In European-supported enterprises, these capabilities facilitate environmental compliance, sustainability reporting, and access to green finance. The integration of biotechnology and AI therefore enables youth-led innovation to progress from experimental solutions toward technically robust, data-driven, and scalable pathways for environmental and economic impact in Egypt.

Development Impact, SDG Alignment, and European Added Value

Investing in youth creativity in biotechnology and AI in Egypt can be analyzed from the perspectives of creating innovative human capital, fostering innovative enterprises, and developing innovations with an impact on sustainability while making a careful distinction between what is observable and what is targetted attempt in the program. On a national scale, investment in the public sector has led to the active participation of over 300 young innovators from 39 public and private universities in the youth innovation program as of the date of this report, with more than 100 million EGP in public funding. These numbers represent the active and advanced or final stage participants of the national programs and do not represent the entire targetted population of those who were exposed to activities of national programs. In particularly training, mentoring and competing the students and project activities the educational impact is large. As a result the wide range of participants in the program have gained different skills and contributed to employability and work practice competencies in the Inter-disciplinary teams which is part of the SDG 4 objectives.

In European-supported acceleration frameworks at the enterprise and labor market level, medium-term structural outcomes are prioritized over short-term project outcomes. With the UNDP Green Growth and Jobs Accelerator under the Danish-Arab Partnership Programme, the target is to assist 800 SMEs by 2027, thereby creating 4,000 direct green jobs and 10,000 indirect jobs

in the associated value chains. The numbers in this case are indicative of potential outcomes to be realized in the future, and not the actual outcomes at the time of analysis. This shows a movement from providing support for innovation to the implementation of employment-related environmentally sustainability policies. The indirect employment effects of the sectors of focus, such as bio-based manufacturing, agri-processing, and environmental services, align with SDG 8 (Decent Work and Economic Growth), as these sectors tend to create more jobs in the value chains than the direct jobs that are created. The SDG 12 (Responsible Consumption and Production) and the SDG 13 (Climate Action), in particular, SDG 13, are fulfilled by the adoption at the enterprises level of resource efficiency, waste valorisation, and emissions improvement. The European and the Danish-Arab Cooperation value addition emanates mainly from the institution and the methodological mechanisms, integrating enterprises to internationally recognized sustainability frameworks, standards, and performance indicators. This allows for enhanced credibility, impact measured in real time, and investment risk mitigation and fosters the exit from insular innovation to a sustained economically developed innovation that is environmentally conscious.

To synthesize the development impacts and their alignment with the Sustainable Development Goals, Table 1 summarizes the key analytical dimensions and the added value of European and Danish–Arab cooperation.

Table 1: Youth Innovation in Biotechnology and AI: Development Impacts and SDG Alignment

Dimension	Key Indicators	Evidence from Egypt	SDGs	European / DAPP Added Value
Human Capital	Participation; skills; interdisciplinarity	>300 finalists from 39 universities; broad skills exposure	SDG 4	Mentorship, international standards, employability focus
Technology	Scalability; efficiency	Bio-based waste valorization; AI-driven efficiency gains (~10–20%)	SDG 9, SDG 12	Validated methods; sustainability diagnostics
Enterprise Impact	SME growth; jobs	Early-stage ventures; 800 SMEs targeted by 2027	SDG 8	Risk reduction; green finance readiness
Environmental Impact	Waste; emissions; resources	Reduced rice-straw burning; improved energy/water use	SDG 12, SDG 13	Harmonized environmental indicators
System Integration	Policy coordination	National ideation linked to international acceleration	Cross-cutting	Institutional coherence; long-term orientation

Limitations

There are many limitations to this research. For one, this analysis depends largely on information that is readily available to the public. This includes information such as the number of participants, available funding, and the goals of the accelerator - as opposed to information such as the financial details of individual firms or details about their performances, if such details are available. The extent to which the young entrepreneurs supported by the programs have been tracked for prolonged periods of time has prevented an assessment of the programs' outcomes on long-term job creation, sustainability, and the continued entrepreneurial ventures' ecosystems' utilization of resources. Furthermore, the development outcomes, particularly the job creation and scaling of enterprises, that are discussed in the study are outcomes that were envisioned and are program objectives, and thus, during the time of analysis, outcomes were not yet realized. These limitations represent the characteristics of the youth innovation ecosystems in Egypt.

Conclusion

This illustrates that young innovators working in biotechnologies and artificial intelligence, with appropriate national and international support and guidance are highly likely to achieve positive and sustainable outcomes in advancing development in Egypt. Youth activation processes, such as the GEN Z innovation program, work successfully to deploy large numbers of young people, enhance capacity, and facilitate cross-disciplinary applied methodologies that test technology in support of sustainable solutions. However, impact flows mainly from the idea and prototype development. There are significant gaps in downstream processes that support the scaling of new solutions and job creation. As in the case of the UNDP Green Growth and Jobs Accelerator within the Danish–Arab Partnership Programme, European support builds the capacity to translate the positive outcomes of innovation into new enterprises and the creation of green jobs with notable improvements in the environment. The combination of biotechnology and artificial intelligence is vital in this context in that biotechnology has the potential to alleviate resource and environmental pressures within Egypt while artificial intelligence provides a means to optimally improve and transparently monitor systems, enhancing scalability and sustained performance.

The developmental impact of these activities is cumulative but not of the transformational kind. It is demonstrated in positive shifts in skills, the performance of enterprises, and the adoption of sustainable practices that meet the expectations of international best practices. European and Danish–Arab collaboration enhances the development of impact measurement systems and allows the alignment of age-based innovations with the investment risk continuum and integration within global sustainable development frameworks. Other advanced economies aspiring to cultivate youth innovation and incorporate inclusive, sustainable technological advancements can draw lessons from Egypt's experiences.

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