

Article

Higher Education Interdisciplinarity: Addressing the Complexity of Sustainable Energies and the Green Economy

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Abstract: Universities play a strategic role towards a sustainable future, as they address the complex scientific research on green transition and enable students from diverse backgrounds to acquire different skills, integrate multiple perspectives, and handle the sustainability of the ongoing and future renewable energy sector. In this paper, we describe a collaborative project between multiple HEIs (European and African) and local institutions, which promotes an interdisciplinary approach to address climate change and green energy transitions in the curricula of universities, used in the context of the ERASMUS+ program (DALILA—Development of new Academic curricula on sustainable energies and green economy in Africa). The project recognizes and values different kinds of knowledge in renewable energy and green economy to address the energy transition in higher education in African countries as a prerequisite for climate change mitigation and sustainable development.



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1. Introduction

Climate change and environmental crises are jeopardizing the sustainability of countries around the globe, calling for global greater efforts to move towards greener societies and economies. This process also involves the creation of new opportunities for technologies, investments, and jobs that pose the central role of universities in the alignment of environment and employment objectives, as recently underlined by the Green Jobs Initiative, a joint effort launched by International Labor Organization.

The paper describes the attempt run by the DALILA project, funded by EACEA, the Executive Agency of the European Commission for Education and Culture for the period 2019–2022 (for more info, please see <https://www.dalilaproject.eu/>, accessed on 6 February 2022), to create on international alliances among universities, local labor markets, NGOs, and society, for the creation of a sustainable ongoing and future renewable energy sector. In fact, the development and diffusion of green energy technologies involve both scientific–technical skills and social awareness; thus, the project and all the associated activities have a multidisciplinary nature to achieve wider uptakes of these technologies within the community. Seeing this complexity, DALILA consortium is made up of different actors: universities (in Europe: Sapienza University of Rome—coordinator of the project—and University of Cadiz; in Africa: State University of Zanzibar, University of Dodoma, Uganda Martyrs University and Uganda Christian University), NGO (A SUD), and incubators and business accelerators (INOMA; Sahara Ventures). This heterogeneity is not only beneficial for the definition of the teaching material and courses offered in the selected universities, but also to provide students with different points of view and skills and to train and inform them on different job opportunities related to the green energy sector.

The involvement of local incubators and business accelerators—Sahara Ventures and INOMA—is crucial to train and support students in starting a business or spin-off in the renewable energy sector. Sahara Ventures, through courses aimed at boosting students' employability and entrepreneurial spirits, supports the creation of a new young Africa's innovation and a technology entrepreneurship ecosystem, whereas INOMA concretely demonstrates to students how to create a "bankable" idea on renewable energy and how to move the first steps from the Universities' labs to small successful businesses. Moreover, the involvement of A SUD, a non-profit civil society organization promoting environmental rights and climate justice, brings an added value into the project by raising awareness among students and, more generally, among the academic and local communities, on the importance to link academic curricula to new environmental and climatic challenges in the framework of the approach proposed by the UN Sustainable Development Goals.

The DALILA project in fact addresses the sustainability of the ongoing and future renewable energy sector in Tanzania and Uganda, training a new generation of energy professionals and strengthening local universities and their innovation capacity following three pillars:

1. Increasing the local competencies on Renewables and Green Economy, and establishing and integrating new modules on "Renewable Technologies" and "Green Business creation and development" into the target universities' curricula
2. Promoting the use of innovative technologies by increasing the capacities of the university laboratories in order to provide practical training for renewable energy and adaptation of technologies to local contexts
3. Increasing students' employability, underlying the potential profitability of renewable energy through business development and management trainings focusing on the local financing opportunities and the legislative framework.

The main joint challenge of the project is to equip students that will enter the labor market with the ability to learn the skills required for adopting new technologies, meeting new environmental regulations, and shifting to renewable sources of energy. In this sense, a multidisciplinary training plays a fundamental role in providing students with greater skills and opening their minds, allowing them to add value to local communities and contribute in different ways to the green transition.

This paper aims at identifying the main challenges of higher education institutions to be able to interpret the complexity of real-life processes by introducing interdisciplinary and international courses within a university culture based on disciplinary faculties. In this sense, the DALILA project can be considered an important building block in creating fruitful international partnerships among different academic and non-academic institutions. These collaborations support the African high education system in the change to energy transition, as a prerequisite for climate change mitigation and sustainable development. We clearly stress how interdisciplinarity in teaching renewable energy and green transition is a cross-cutting issue that should be implemented in all processes, from the identification of local needs to the choices of didactic materials and students' curricula.

The paper is organized as follows. The next Section explains the strategies adopted by HEIs involved in the DALILA project for the identification of the local needs, that involves an *ex ante*, *in itinere* and *ex post* evaluation of the main urgencies and local economic, social, and environmental problems. Section 3 stresses the importance of internationality and interdisciplinarity in teaching the complex nature of renewable energy and climate change. After identifying the challenges for international and interdisciplinary HEI in Africa, the section describes the didactic approach used in the DALILA project for educational activities aimed at comprehensively addressing these two topics. Section 4 defines the role of non-academic entities working in the renewable energy and sustainable development sectors in creating a link between universities and labor market in the project. The final section provides some concluding remarks.

2. Step 1—Identification of Local Needs: Empirical Research, between Literature and Reality

The multidimensional nature of climate change determines the choice of a main analytical approach for environmental, social, and economic sustainability that adequately represents the local needs. Therefore, the first step in the development of new interdisciplinary courses is a preliminary identification, with an *ex ante* evaluation, of the main urgencies and local environmental problems.

In the context of the DALILA project, a macro analysis of local needs has been first defined, as outlined in the main reference literature. At a later stage, micro investigations, such as surveys and interviews, monitored whether the project was meeting the real local needs of the target groups (*in itinere* evaluation). During the entire project lifetime, it is in fact crucial to regularly evaluate to what extent the local needs are aligned with the actions performed. In addition, a final evaluation (*ex post* evaluation) will be required to determine the degree of sustainability of the project after its conclusion and to foresee its possible replicability in other contexts (see Figure 1).

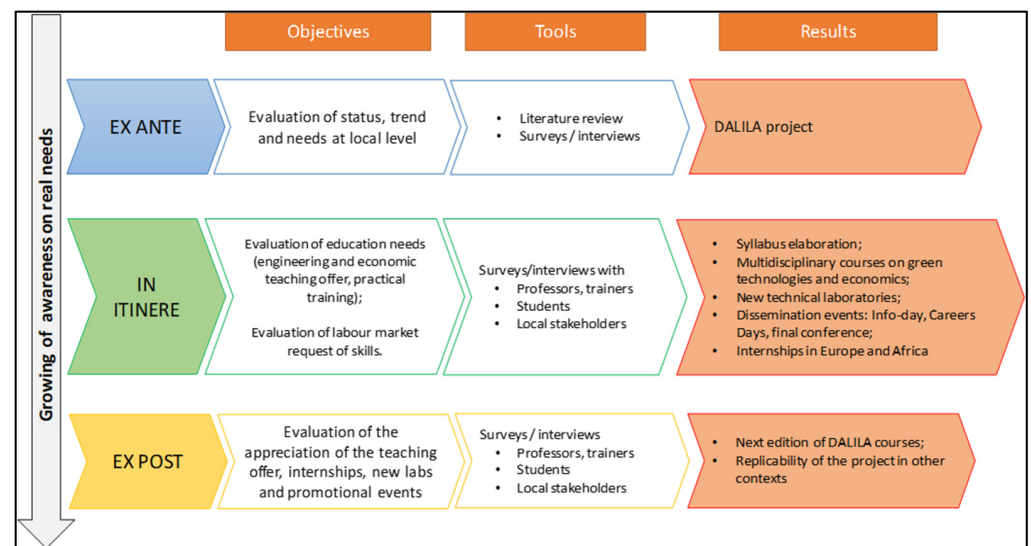


Figure 1. Process of evaluation of local needs during the entire duration of the project.

During the identification, implementation, and evaluation of the activities, it is also important to consider the involvement of different actors:

- The private sector, such as industries, companies, and providers, is key for students' employability and to create links with academia to support graduates in building their own social enterprise or spin-off company.
- The public authorities, such as local government authorities (at District level, Local and Regional Energy Agencies (LAREAs) and regulatory bodies, National Coordination Groups, and the Ministries of Education and Energy) are key to gain political awareness, commitment, and support to young generations that are about to become the professionals of tomorrow.
- The civil society representatives, e.g., NGOs, community-based groups, and/or organizations, can offer internships to students and to build partnerships with academia for joint training, research, coaching, consultations, for those who work in remote rural areas where energy issues are crucial.

2.1. Macro Analysis of Local Needs (Ex Ante Evaluation)

African countries are particularly vulnerable to climate change and the lack of a correct strategy for a sustainable transition toward green development can irreparably affect the ongoing progress in the area. The African Union Agenda 2063 represents the official commitment for building a more prosperous continent in the next 50 years, being integral

part of the 2030 Agenda for Sustainable Development. In the Joint Communication for a Comprehensive Strategy with Africa (adopted on 9 March 2020), Europe and Africa agreed to pursue sustainable pathways to development through a low-carbon, climate resilient, and green growth trajectory, leapfrogging fossil fuel based and inefficient technologies [1].

The temperature increase caused by climate change has dangerous effects on the African population, mainly on those people living in the cities and in poor conditions who are, in general, not conscious about the heat–health relationship [2]. Due to the growing population and economic progress, the energy demand is rapidly increasing, making the design of sustainable strategies for energy supply a priority. Despite Africa is the richest continent for conventional and renewable sources, in Tanzania, only 38% of the population has access to electricity: 73% in urban areas and 19% in rural areas, and about 36 million people do not have access to it [3]. The United Nations (Economic Commission for Africa) estimates between 110 GW and 200 GW the additional potential of renewable energy compared with the power already installed of 230 GW in 2017, with an investment opportunity of USD 400 billion [3].

Despite National Energy policies aimed at supporting the transition from biomass to electricity, charcoal remains the cheapest and most widely used fuel in the residential sector in Tanzania [4]. A successful strategy must be tailored on local needs, sources, culture, policy, and economic potential. The concept of Climate Compatible Development (CCD) explains how development should minimize the harm caused by climate impacts, maximizing the human development opportunities allowing low emissions and a more resilient future [5].

For the African Countries is important to understand how renewable energy policies pay attention to social and ecological equity, introducing the concepts of “just transitions” and “energy justice” [6], especially when applied to vulnerable groups. Many studies identify in market-led and donor-led policies a good solution for driving the transition to renewable technologies, which can be reached through the scalability of a national strategy considering local and national needs [7]. Urban areas, which saw a rapid growth of inhabitants over the last years, represent a suitable space for a sustainable transition, as they leverage “economic ecosystems” for local scale social innovation-based development interventions. An innovative entrepreneurial state-led approach at local scales meets local and regional demands through decentralized, low cost, small-scale infrastructures, technologies and services [8].

The general definition of renewable energy considers many technologies; however, not all of them can be successfully applied in Africa. Four modern technologies have been identified as those with the highest potential: biomass for cooking, hydropower, wind, and solar power [9]. Renewable technologies allow the transition from concentrated power plants to distributed solutions that can support the social and economic development of poorer populations: energy mini grids can play a winning role in the achievement of universal access to electricity. Despite the high clean energy potential and the availability of technical solutions, the latter alone does not guarantee success of renewable technologies’ installations. Therefore, new business models are crucial to avoid dissatisfaction of users and service disuse [10]. Global growth should go through the application of suitable technical, political, financial, and social strategies with long-term implications.

All the above-mentioned issues are taken in consideration in the design of the DALILA teaching methodology and in the identification of new courses. As energy and sustainable transitions need experts with transversal awareness and competencies, DALILA teaching package includes courses on both technical and business topics. Energy problems are approached from an energy saving and management perspective, with the idea that less consumed energy (for the improvement of technology efficiency) corresponds to non-installed plants and reduced emissions. Renewable technologies should work to supply the necessary amount of energy, and the selection of the best solution starts from a critical analysis of the context, needs, available primary sources, existing infrastructure, and possible investments. In the new academic courses, priority has been given to tech-

nologies that are already recognized as promising in Africa, such as photovoltaic systems, solar thermal collectors, wind farm, biomass. They are taught starting from the basics, the description of the physical conversion to energy, the technologies used, but also norms and regulations, practical applications, and some case studies. The concept of sustainability is widely explained, showing the different levels of application in various aspects: energy, society, cities, and economy. The adoption of renewable solutions and the growth of a sustainable market go through the knowledge of applicable business models and financial strategies. For these reasons, DALILA courses also offer an overview about the main financial instruments and incentives for the promotion of renewable technologies and energy efficiency interventions connected with the local needs. Great emphasis has been devoted to less mainstream resources available for financing renewable energy projects, such as Islamic finance, microfinance, crowdfunding model for green energy investments, academic start-ups and spin-offs, and local accelerators/incubators. Moreover, to highlight the importance of a sustainable business pattern, the analysis of energy cooperatives and renewable energy projects where community-based organizations, rather than centralized rural electrification agencies, manage the local electricity supplies, has been included in the courses. Concerning the topics of project financing and evaluation for renewable energy and energy efficiency, lectures on social marketing for renewable energy are also provided, with the support of Minerva Lab, Laboratory on Diversity and Gender Inequality in Sapienza University of Rome (<https://web.uniroma1.it/labminerva/en>, accessed on 6 February 2022). Minerva Lab will help addressing the importance of the role of women and youth in climate change, renewable energy, and green transition.

2.2. Micro investigation of Local Needs (in Itinere Evaluation)

To identify how DALILA specifically needed to address the issues explained in the past paragraph and tailor its impact *in itinere*, an investigation on the awareness and satisfaction of the target groups (student and staff) towards the project topics was carried out as each deliverable was implemented. Although it was possible to identify the macro local needs through an exhaustive literature review, the problems directly experienced by the target groups needed to be differently identified. For this reason, the beneficiary universities (lecturers, staff, students) and the representatives of some local key stakeholders were interviewed at the beginning of the project lifetime. In addition, the target groups were asked to answer various surveys as the project evolved to gauge their satisfaction with the activities.

Seeing the high unemployment levels and the issues the continent is facing with the green transition, one of the main goals of the DALILA project is to facilitate the access to the labor market to high-education students. In this view, including multidisciplinary competencies in the universities' curricula is crucial. The DALILA program has thus dedicated an entire Work Package to the expertise of non-academic entities in support of the green transition, to connect the beneficiary universities with the labor market and the decision makers area.

To put this into action, three steps have proved to be effective in building and developing connections with non-academic stakeholders:

- The approval of DALILA courses within beneficiary universities' academic curricula: the National Authorities for Education (the National Council of Higher Education in Uganda and the Tanzanian Commission for Universities) were involved during the first year of the project.
- Info days: events organized at local level to raise awareness on the risks connected to climate change and on the necessary environmental protection strategies, to increase students' interest on green technologies and economy, motivating them to attend DALILA modules. The representatives from the Ministries of Energy in the two countries were involved, as well as the Tanzania Geothermal Development Company (TGDC) and the Tanzania Renewable Energy Association (TAREA).

- Scientific Symposium on Green topics: a virtual event-due to the current COVID-19 pandemic-that engaged different companies working in the renewable energy and recycling sector, to strengthen the links between the partner universities and the labor market.

In particular, the Scientific Symposium was divided into three parts, to address different target groups and topics:

1. Institutional: the high representatives of DALILA's Partner Universities virtually met to reflect on the current issues of sustainable development in Africa and to encourage an open discussion on how these can be improved through the collaboration of the African-European high education system. All Partner Universities' Rectors, Vice-Chancellors, and other representatives presented their Institutions and highlighted the importance of a transversal collaboration at academic level to tackle the complexity of the African green energy and renewable energy sector.
2. Academic: the economic and technical courses developed from the collaboration of all DALILA Partners were presented to the university audience (professors, staff, and students). The aim of this event was to illustrate in detail the courses and their contents, enhance the interest of the academic community toward them, and promote the enrolment of students at the Beneficiary Universities.
3. Academic-work sector: partner universities and labor market representatives met to discuss the job opportunities in the green sector in Africa. Various companies working with renewable energy, waste management, and green technology were invited to talk to students about how to build a successful business and invest in the sector to tackle unemployment and the issues related to the climate crisis.

In the framework of DALILA, the Scientific Symposium on Green topics was a determining factor to involve an increasing number of people and to spread awareness on the project goals. This event was used as benchmark to measure how effectively DALILA deliverables were applied and how the beneficiary community was responding to them. As a matter of a fact, this event contributed to the improvement of the dissemination and communication of the project activities to the wider community, which showed a higher degree of engagement in the project news and information. The data on the participation to the three sessions were collected to analyze how the project is impacting DALILA's main target groups, namely African students, and the degree of the beneficiary institutions' active participation (see Table 1).

Table 1. Number of participants and target groups of three-day Scientific Symposium.

Day	Participants	Gender	Job Position	Beneficiary University
1—Institutional profile	68 from Africa: 58	M 62% F 38%	Prof/Teacher/Trainer 47%	UCU 34%
			Staff 18%	SUZA 26%
			Student 15%	UMU 24%
2—DALILA courses	97 from Africa: 89	M 67% F 33%	Head of Department/centre 10%	UDOM 16%
			Vice-chancellor/rector 4%	
			Other 6%	
3—Labor market	46 from Africa: 31	M 54% F 46%	Student 60%	UCU 75%
			Prof/Teacher/Trainer 23%	UMU 11%
			Staff 8%	UDOM 8%
			Head of Department/centre 4%	SUZA 6%
			Other 5%	
			Prof/Teacher/Trainer 39%	UCU 29%
			Head of Department/centre 26%	UMU 29%
			Student 22%	SUZA 26%
			Staff 6%	UDOM 16%
			Other 7%	

The participation data showed in Table 1 identify more concretely the major issues on which DALILA has been working since the beginning of its implementation:

- (a) Boost gender equality: the entire event was attended by a higher number of men. To have a positive impact on gender equality and any other form of discrimination, specific actions will be taken during the project lifetime, such as student selection for the business courses will be based on equality and diversity principles; didactic courses will be promoted in view of gender equality.
- (b) Encourage a stronger participation of students in all activities: e.g., they designed the project logo; info days to build connections with them; create links between universities and labor market for job experiences (Employability Hub, business modules, internships at local companies, visits of companies working in the renewable energy field at the academic institutions, etc.).
- (c) Promote all partners' equal participation to the activities of the project: e.g., each beneficiary university has been assigned to lead one Work Package based on their strength; Beneficiary Partners are consulted before taking any decision relevant to the project and are always asked to give their opinions and contributions to every activity.

Furthermore, the Scientific Symposium's participants were asked to respond to a survey in order to examine which opportunities the African green market is currently offering to students who are about to enter the labor market, and what are the actions that the academic community would have to undertake (Figure 2). The participants (we interviewed 16 people) stated that the biggest obstacles from entering a career in the energy sector in Africa are connected to a lack of (1) mentoring activities and training, and (2) adequate skills and platforms where it is possible to exchange professional experiences and job offers. Furthermore, the webinar highlighted the importance of a virtual space to create a bridge between job offers and demands in Africa, and to inform students on the entrepreneurial opportunities offered by the green market. Based on the information exchanged by companies working in the energy and waste management field, the interviewees informed us on the most important actions they think high education institutions should undertake to enhance the employability of students in green economy.

However, participants confirmed that after this event they felt more informed about the different opportunities of employment in the new field of green economy and sustainable development. The students that responded to this questionnaire said that they are willing to take part to DALILA courses, as these will inform students on the topics mentioned above, and that they feel motivated in carrying out internships with companies, institutions, associations, and NGOs operating in the green sector, as the collaboration between high education institutions and external bodies is useful to tackle the issues related to unemployment and climate crisis in their Countries.

DALILA courses are currently being taught at the University of Dodoma (where one has been completed) and Uganda Martyrs University, whereas they are about to start at the State University of Zanzibar and Uganda Christian University. As an additional tool to measure the degree of engagement and satisfaction at the beneficiary universities, students enrolled at the University of Dodoma were interviewed after attending the first DALILA course "Renewable energy technologies and decentralization of energy production". A total of 87% of them felt highly satisfied with the way the topics on renewable energy technologies and energy production were discussed, and with the didactic material provided. A total of 57.1% stated that the main area of interest for a possible postgraduate specialization path or job application is renewable technologies, followed by energy efficiency (28.6%) and circular economy (14.3%). Most students are also motivated in carrying out an internship with a company working in the green sector. After attending this course, students appreciated the importance of practical learning, which they think is the main action their institution should undertake to enhance employability. Finally, they unanimously showed interest in attending further courses implemented by the DALILA project.

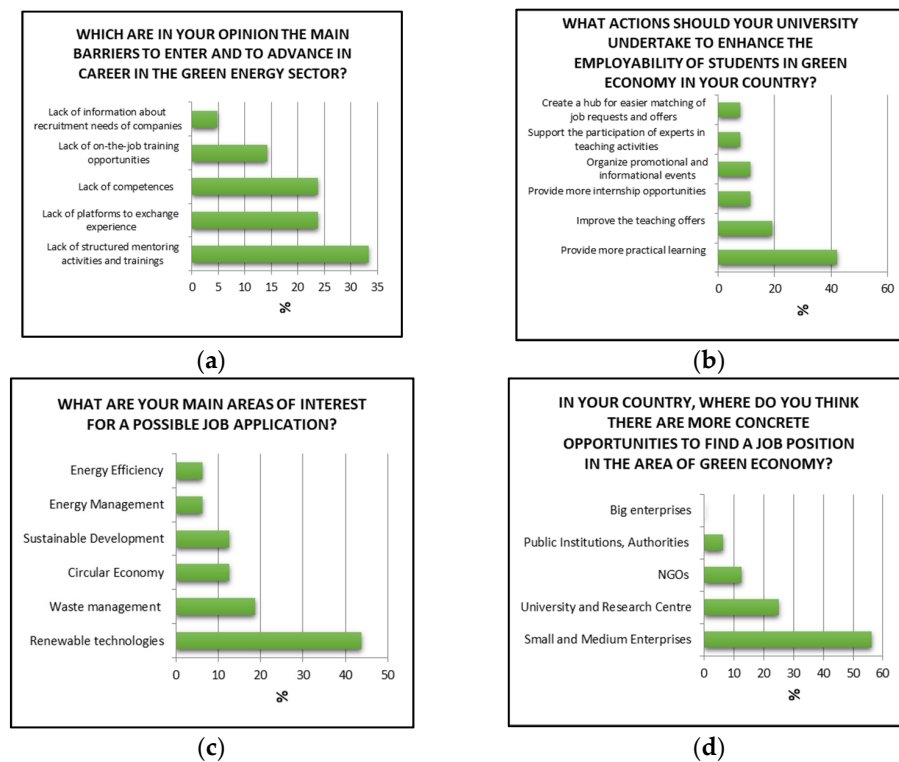


Figure 2. *In itinere* evaluation of the project, (a) Which are in your opinion the main barriers to enter and to advance in career in the green energy sector?; (b) What actions should your university undertake to enhance the employability of students in green economy in your Country?; (c) What are your main areas of interest for a possible job application?; (d) In your Country, where do you think there are more concrete opportunities to find a job position in the area of green economy?.

The questionnaires submitted to students and stakeholders over the course of the first two years of the project proved to be essential to gauge the degree of satisfaction with the topics offered by the project, and the way they were implemented at the Beneficiary University. Teaching this first DALILA course as part of the African curricula served also to spread some light on what is currently missing in their high education system, as well as to raise awareness and deeper knowledge of young generations in relation to the green transition. Students will be interviewed after completing each learning cycle (courses, trainings, internships) to closely monitor the impact DALILA is having on their learning process, at both theoretical and practical level, and on their awareness on the relationship between university and the job market.

The *in itinere* evaluation has been especially important to cope with the challenging time during which the DALILA project has been implemented. Not having the possibility to relate more closely with the involved students and lecturers has affected their degree of attention and engagement towards the project activities from time to time. In this regard, the use of surveys, but also of email correspondence and social media, has proved to be effective in encouraging the interest of those participating at different levels to the DALILA project, and arouse the curiosity of the both the academic and non-academic communities.

2.3. Final Evaluation (Ex Post Evaluation)

A final evaluation will be conducted after the project completion to assess whether the interventions operated by DALILA effectively worked in the target territories (Tanzania and Uganda). This evaluation will not only provide qualitative and quantitative data on the achieved objectives but will also help determining if any unintended effect was achieved. *Ex post* evaluations put an emphasis on the effectiveness and sustainability of the project: the former mainly refers to check whether DALILA project delivered all the predetermined

goals and if they produced the expected benefits, such as: (a) improved awareness towards the importance of renewable sources and of energy sustainable development, not only from the academic population but also from the wider community (those living in rural areas or with scarce access to high education); (b) the creation of job relations between universities and local labor market; (c) an improvement in equalities to access higher education. On the other hand, measuring the efficiency of the project during and after its lifetime aims at providing lessons on how to improve planning similar projects in the future in a more efficient way. Sustainability is a crucial aspect of projects revolving around education: an *ex post* evaluation assesses the sustainability of results and impacts; however, some time has to pass between the project end and this assessment—typically between 1 and 3 years.

3. Step 2—Definition of Interdisciplinarity and Internationality in DALILA Courses

In 1963, Karl Popper wrote: “We are not students of some subject matter, but students of problems. Additionally, problems may cut right across the borders of any subject matter or discipline” [11]. When a problem appears to be too complex to be addressed by only one discipline it should then involve different ones at theoretical, conceptual, methodological, or empirical level. This is certainly true for renewable energy and climate change. These issues are interconnected with ethical, social, economic, technological, ecological, spatial, design, and political aspects that, only as a whole, can construct the holistic scene for understanding and teaching them appropriately. As a matter of fact, climate change and renewable energy are intrinsically covered by various bodies of sciences. As a result, they pose a challenge for pedagogy since they should not be treated monolithically but rather in a holistic manner. As suggested by Cortese [12] “Designing a sustainable human nature requires a paradigm shift toward a systemic perspective emphasizing interdisciplinary understanding, collaboration, and cooperation that must be led by higher education”. Hence, it is important to define a common framework to integrate different fields of study and complex nature of renewable energy and climate change in high education courses in a way that these concepts can be individually discussed and emphasized accordingly.

An interdisciplinary approach on research in the context of renewable energy and climate change is becoming more and more visible in the scientific literature (Table 2). For instance, over the last years (from 2015 to 2021) the search engine Google Scholar shows different articles whose titles contain both “Renewable Energy” (“Climate Change”) and “Interdisciplinary”. In a pedagogical context, this refers to the ability of students to access a range of courses from various disciplines to acquire knowledge on complex issues.

Table 2. Number of publications with the words “Renewable Energy/Climate Change” and “Intradisciplinary” in the titles: 2015–2021 in Google Scholar.

Words in the Titles	No. of Publications
“Renewable Energy” and “Interdisciplinary”	7
“Climate Change” and “Interdisciplinary”	110

However, the efforts of higher education to approach the energy transition as a prerequisite for climate change mitigation and sustainable development, in particular in teaching activities, are still insufficiently studied. HEIs are increasingly aware of their role for the development of capabilities needed to support the transition to sustainable paradigm [13–15] generating social awareness and critical thinking [16] in line with the commitment taken by the international community during the Rio +20 Conference United Nations Conference on Sustainable Development in 2012: “We recognize the important contribution of the scientific and technological community to sustainable development. We are committed to working with and fostering collaboration among the academic, scientific and technological community, in particular in developing countries, to close the technological gap between developing and developed countries and strengthen the science-policy interface, as well as to foster international research collaboration on sustainable develop-

ment" ([17], p. 47). Following this trend, on December 2015, a global alliance of higher education sustainability networks, representing more than 3000 universities and colleges worldwide, jointly issued an Open Letter urging Ministers and Governments to acknowledge and strengthen the research and education role that universities and colleges play in addressing climate change. The Open Letter to COP21 Ministers and Governments [18] stresses how the complexity of climate change requires "more support for transdisciplinary learning, teaching and research approaches that link climate solutions with the need to transform economic, political and social structures." Moreover, concerning renewable energy, the UNESCO Berlin Declaration on Education for Sustainable Development (adopted at the UNESCO World Conference on Education for Sustainable Development in 2021) focused on the role of HEIs in ensuring an equitable and inclusive access and use of new, digital, and 'green' technologies "based on critical thinking and sustainability principles with a proper assessment of risks and benefits", as well as promotion of open educational resources, open science and affordable e-Learning facilities [19]. Within these agendas, universities emphasized interdisciplinary approaches to teaching renewable energy [20] still facing significant challenges in implementing them. HEIs struggle to find effective methods for implementing sustainability in teaching within university campuses and they also face structural challenges to implement sustainability agendas. Citing Verhulst and Lambrechts, the main constraints and barriers are poor information and communication, resistance to change, lack of technical skills for implementation and most of all "lack of interdisciplinary research as a result of insufficient coordination and cooperation" ([21], p. 191). In fact, a contemporary theories of knowledge democracy tends to emphasize the importance of teaching in HEIs for the 'co-construction of knowledge', that involves the liaison among local and international HEIs and non-governmental organisations (NGOs) to organize teaching activities in the framework of transdisciplinary and sustainability in higher education [22]. Therefore, cooperation between HEIs through collaborating in international programs is an important measure to promote and disseminate teaching methods regarding climate change and renewable energy. DALILA is an example of collaborative projects between multiple HEIs (in this case, from Europe and Africa) and local institutions that promote interdisciplinary approaches to address climate change and green energy transitions in the curricula of universities. DALILA in fact designed new courses on green energy and renewable energy connected to the core curricula in engineering and economics departments in African Universities, sufficient to prepare students to make the necessary decisions in their daily lives to address sustainability challenges both in technical and socio-economic perspectives.

3.1. Challenges for International and Interdisciplinary HEI in Africa

Although it is possible to discern three historical phases in the attitude of the East African universities—from high level manpower training to teaching and research in local needs and problems to more emphasis to field work and the encouragement of locally authored teaching materials and graduate programs [23]—in the 1973 report on Creating the African University, Yesufu clearly stressed that "the truly African University must be one that draws its inspiration from its environment: not a transplanted tree, but one growing from a seed that is planted and nurtured in the African soil" ([24], p. 33). This, however, should not imply that the seed planted and nurtured in the African soil does not take advantages by contaminations produced outside the continent. Although the decolonization of the curriculum is an important issue [25,26], the question of what ought to constitute a "Africanised African higher education curriculum for sustainable development remains unanswered and unaddressed in most of the current curricula of higher education in Africa" ([25], p. 49). Many institutions of African higher education have already reached excellence not only in academic subjects, such as green campuses, with manifold ethics curricula and in their community engagement, but also in the value-orientation of both teaching staff as well as students. Therefore, the co-creation of courses in the framework of the DALILA project on green energy transition between European and African universi-

ties required a balance between the national and international character of curricula for students, reorienting what is taught at a university to select and focus a combination of different disciplines on the green transition's concerns of a particular region in which it is located. Therefore, the main challenges in the design and implementation of the new courses have been to be culturally close to society and at the same time be intellectually linked to wider scholarly and scientific values of the world of learning. In line with the 2021 World Bank's Higher Education for Economic Transformation Project set to boost Tanzanian higher education through "curriculum review and reform, which will include introduction of innovative pedagogy and responsiveness to growing climate change issues" (<https://documents1.worldbank.org/curated/en/851851616414116600/pdf/Project-Information-Document-Higher-Education-for-Economic-Transformation-Project-P166415.pdf>, last accessed date 9 January 2022). The DALILA project aims at fostering contamination, cooperation, participation, and collaboration between European and African HEIs and local institutions recognising and valuing different kinds of knowledges, epistemologies and knowledge cultures in renewable energy and green economy.

For this reason, the DALILA project pilots a new didactic approach for educational activities aimed at comprehensively addressing these two topics. Teaching them in an integrated way requires a proper teaching method to enable students to (1) understand crucial climatic processes and their different impacts, (2) comprehend core technical and economics/business administration elements of renewable energy, energy efficiency and sustainable development, and (3) discuss and even innovate strategies for different stakeholders, labor markets, and local needs. Implementing interdisciplinary courses within a university culture that is organized along disciplinary faculties turned out to be a major challenge in designing and managing the project. However, with respect to teaching, we noted a strong level of commitment and a high propensity to innovation and to implement new teaching materials among all local partners' units.

The didactic approach that we pilot can be framed as a circular flow made up of 4 main objectives that are strictly interconnected that we used to define the implemented activities (see Figure 3). The four goals that guided the activities of the project put students at the centre of the process to allow them to:

1. Understand core technical and economic concepts related to renewable energy, energy efficiency, and sustainable development
2. Increase interdisciplinary exchange and cooperation
3. Strengthen the critical analysis of complex problems
4. Booster adequate knowledge and capabilities to meet local job market's requirements in renewable energy.

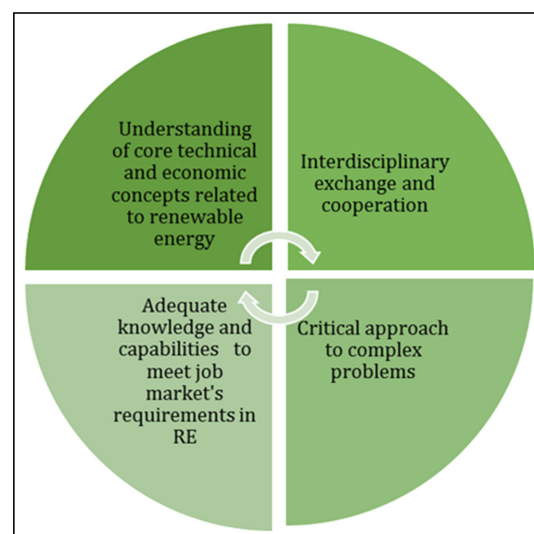


Figure 3. Objectives for the didactical approach of DALILA project.

We used the circular flow depicted above to frame six new courses on green and renewable energy to be integrated in the core curriculum of the African universities (see Table 3 for a full description).

Table 3. Description of the main contents of DALILA courses.

Business and Financial Models for Renewable Energy
The course mainly explains the business model innovations, their applications and how they can be designed as well as redesigned. Evolving business models for renewable energy in terms of revenue models (pricing of renewable energy power under various frameworks including fee-in tariffs and auctions), operational costs (fixed, variable, working capital) and other sources of income (carbon credits, tax credits) are explained.
Renewable Energy Financing and Modelling
The main objective of the course is to enhance the understanding of different financial actors and products (equity, loan, bond, leasing structures, guarantees, Islamic financing structure) in renewable energy. The training equips students with the latest information on financing all types of renewable energy projects to allow them to continue to participate successfully in the Renewable Industry, both in Africa and globally. The course analyses also the role of microfinance in increasing the access to renewable energy micro and small enterprises (MSEs), enhancing the productivity and the business opportunities of MSEs through energy-efficient solutions.
Renewable Energy Enterprises' Management-Support to business and enterprises in RE
Renewable energy technologies and decentralization of energy production
The course introduces renewable energy and technologies highlighting the working principles of solar photovoltaic and thermal systems, hydro, biomass, wind as well as other renewable energy sources that can be developed in Uganda and Tanzania.
Energy and Sustainable Development
The course handles the interrelation of energy that is renewable and non-renewable with the environment reflecting the sustainability aspects such as economic, environmental, technical, socio-cultural ones.
Energy Efficiency (Residential and Industrial Sectors) and Storage Applications
The course aims to introduce the concept of energy efficiency and how it may be applied for carrying out all types of energy-dependent activities, such as manufacturing products, heating/cooling buildings.
The main objective of the course is to give practical information and knowledge about the legal and political framework of renewable energy enterprises' management in the local context and its evolution in the recent past.

We all agreed to move from a 'knowledge-oriented approach' with professors as the key element, to a 'learner-oriented approach', in which courses are student-centric and defined to improve the development of students' knowledge and understanding of the various and complex areas of an ever-changing society and workforce. This knowledge must include the capacity to judge inconsistencies, the ability to create solutions, communicate results, and to focus on several subject specific as well as transversal competencies to be applied in practical contexts. For example, all around the world there is an increasing attention for promoting green growth in several ways:

- Increasing countries' capacity to assess the macroeconomic and fiscal impacts of mitigation and adaptation policies
- Providing green finance
- Improving capacity for environmental fiscal reforms
- Integrating climate issues into medium-term fiscal frameworks, development policy, and other all other national expenditures.

Moreover, the challenges in financing green transformation include:

- Smart subsidies and tax incentives
- Public-sponsored enterprises
- Risk-reduced credit and flex loans
- Green energy Business incubation
- Crowdfunding
- Universities' spin-offs.

Therefore, DALILA courses cover all these issues, not forgetting that the green revolution and so the green economy should guarantee sustainability having as main targets

poverty reduction and gender equity. To be effective, the economic transition to green economy should be more inclusive. In fact, the global energy transition offers an opportunity for deep societal transformations and students should be aware that this is an opportunity for a transition to a more inclusive and equal society. This includes the principles of gender mainstreaming and gender budgeting not only into international and national policies and programs, but also in education and training policies, considering the great heterogeneity across people, countries, and also regions within the same country. DALILA courses also included a gender mainstreaming of energy transition: women participation in the formal labor markets among the countries involved in the project is a factor to take into account (see Table 4), considering the diversities in each country and the best strategies to adopt.

Table 4. Differences in the levels of education, participation in the formal labor markets for women among the different countries involved in the DALILA project.

	Tanzania	Uganda	Italy	Spain
% women completed short-cycle tertiary education	1.3	5.5	13.3	26.6
% women NEET (youth not in education, employment or training)	19.0	8.4	21.4	16.2
Mortality rate for ambient air pollution for women (per 100,000 female population)	135.0	155.0	11.0	6.0
% women employed in Vulnerable employment	88.0	82.5	13.4	8.4
Women in formal salaried jobs	10.2	15.0	83.1	88.2

Secondly, all universities involved in the project agreed on a common framework to describe courses in terms of workload (number of frontal lessons), level, learning outcomes, competencies, and profiles.

3.2. Creation of the Common Syllabi of DALILA Courses

A common template for the syllabi was drawn up by the Scientific Committee before the selection of the topics. The template reports the specific contents requested by European and African (Uganda and Tanzania) Ministries of Education to respect both educational standards. 6 common syllabi to be integrated in the Economics and Engineering faculties' core curricula were created. In doing this, the first step was starting from a simple description of each course collecting the inputs coming from economics and engineering professors and researchers from all universities involved. Each university autonomously defined a list of subjects (and connected sub-subjects) for each course. Sapienza University, as project coordinator, collected all contributions and created a draft version of the courses that was shared and discussed with all units' members through several online meetings. A semi-final version of the syllabi with a detailed list of topics was then prepared and disseminated among the units' members for approval. This process involved the joint scrutiny of the beneficiary universities' professors in economics and engineering, who took into account that the materials and methodology could be easily understandable from students with different backgrounds. Following the syllabi approval, the non-academic partners (A SUD and Sahara Ventures) contribution was required to include the local labor market's and communities' socio-economic and technical needs. After the non-academic additions were implemented, the syllabi were shared and approved by the Steering Committee. The process for the creation of DALILA syllabi described above is reported in Figure 4.

Unfortunately, the DALILA project was implemented during the COVID-19 pandemic and was subjected to the resulting restrictions on international mobility. Therefore, the creation of a common virtual space for sharing experiences, ideas, and teaching methodologies among all partners has been necessary and proved to be particularly important for the process of production and implementations of the courses. To increase commitment and active participation from all partners involved, we collected different resources, useful for supporting the teaching activities (including lesson plans, sample papers, handbooks, academic papers, videos). We asked partners to share different kinds of teaching materials, from Power Point presentations to academic papers and e-books, in order to define

an inclusive list of references that could not only represent the international and local studies but also etherodox economic literatures to adequately reflect a critical approach to sustainability (a specific Moodle area has been created for this purpose in the official DALILA website).

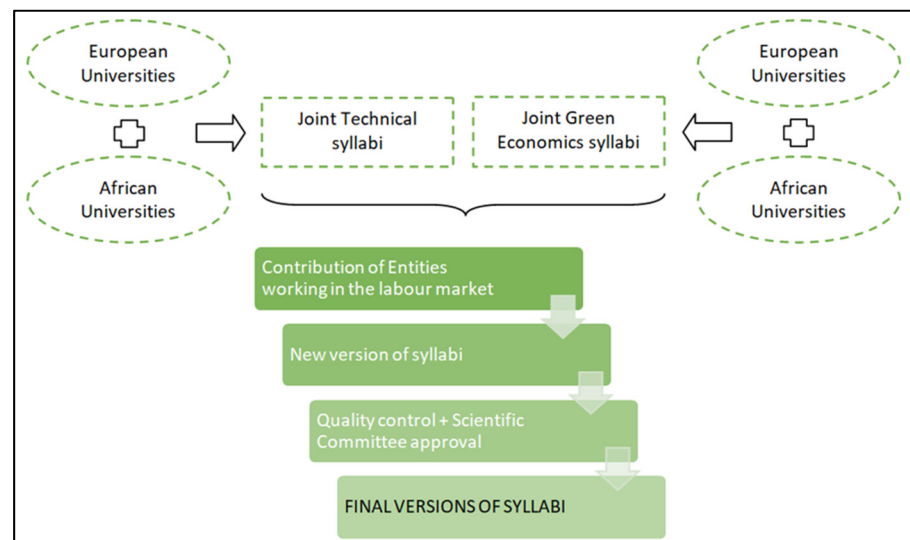


Figure 4. Process for the definition of international interdisciplinary syllabi for the DALILA project.

We received many inputs and learned that videos and recorded lectures are regularly uploaded on YouTube as part of teaching programs in the partner universities. Conversely, this methodology is not recognized as a teaching material from the European side involved in the project. This evidence highlighted the importance of MOOCs (Massive Open Online Courses) and videos to be implemented in the academic courses. The main challenge concerning the teaching materials was the harmonization of all contributions to produce one final document per course and the MOOC elaboration. As by definition, MOOCs should provide free education to large numbers of students, we conceived a format that was able to deliver simple topics in a clear and precise way. To do this, we prepared short videos to provide students real-life examples and describe best practices.

In addition, we conceived the teaching notes, another tool to support lecturers in thinking of ideal scenarios on how the class sessions may be structured. Therefore, the teaching notes can be seen as main reference for the adoption of a common framework for all DALILA courses from different fields of research and contexts.

Finally, for the creation of the teaching notes and MOOCs, we always kept in mind that meaningful learning of concepts takes place when:

- (1) The concepts are clearly defined
- (2) Clear exemplars are provided in order to link concepts to reality
- (3) The concepts are integrated with existing knowledge
- (4) Students are properly motivated to learn the topics.

During each phase of the academic courses planning, creation and delivery, the involved professors' and researchers' commitment was strong. However, the main obstacle to their implementation has been found to be the study programs' rigidity of examination regulations. Implementing interdisciplinary courses on a broader scale would be much easier if there were flexible slots within degree programmes in all the HEIs.

4. Step 3–Booster the Connection between Universities and Local Labor Market

Another key objective of the DALILA project is creating a link between universities and labor market. To make this possible, DALILA has involved non-academic entities working in the renewable energy and sustainable development sectors for:

- The development and implementation of course contents answering to the request of specific skills and capabilities
- Providing training in collaboration with local business consultants and business accelerators
- Ensuring employability of students after the end of their studies
- Using IT services to create a placement platform for students (e.g., “E-mployability hub”).

The involvement of non-academic entities stems from the necessity to create modules and practical trainings specifically tailored on the economic and business aspects of the green market. In this regard, a training “Business skills lab: how to create green business”, has been conceived to teach how to start a business in this specific field, and it aims at equipping students with the foundational skills, knowledge, and resources required to build their start-ups.

The final goal is to form high quality students to be the engine of a positive change at a local level, maintaining a competitive advantage in the global market. Offering to students the supplementary module on “Business skills lab: how to create green business” is a way to channel the beneficiary universities’ curricula towards modernization, accessibility, and internationalization. Including multi-disciplinary courses in their programs putting special attention to the technical and business skills required by the local labor market is important in the process of creating expertise to build successful businesses and invest in the green sector.

Another key element associated with the non-academic partners is to liaise local universities with employers and local businesses to create work experience opportunities for students. This goal is pursued through:

- (1) Visits of existing local businesses working in the renewable energy sector and sustainable development
- (2) The creation of a web platform to connect students with local enterprises to support their employability after their studies.

The collaboration of the local business incubators is essential to train and support the future micro and small entrepreneurs aiming at building a new young local innovation and technology (IT) entrepreneurship ecosystem. The use of IT is particularly encouraged: practical trainings on the digital approaches of the market strategy will be included in the business module.

In addition, the platform “E-mployability hub”, a digital space where students can meet the local labor market representatives, has been designed and included to the official website of all Beneficiary Universities in support to students’ employability: The local business incubator, Sahara Ventures, will support students in the elaboration of this platform, which will include information about the local green market and enterprises’ job offers.

The goal of the “E-mployability hub”, is to help students access jobs opportunities and develop skills and capacity in the green sector. It contains capacity building resources (e.g., DALILA courses and industry events) that provide students quality learning and international qualifications. Alongside, the Hub contains various job opportunities (for internships and employment) from local private companies, public companies, or start-ups and local non-profits. An example of this platform’s envisioned design is provided below (Figure 5).

The activities illustrated above are a clear sign of the importance of the cooperation between universities and the non-academic field, to support students’ employability. DALILA therefore puts special effort in supporting the beneficiary universities to create links with bodies operating in the renewable energy, energy efficiency, and sustainable development sectors, as well as in similar areas students may find appealing for their future career. As the involvement of stakeholders is key for the sustainability of the project, different entities, such as the private sector, NGOs, central and local government representatives, research centers, etc., should be involved in different activities throughout the entire duration of the project. As students previously identified the lack of practical learning in their university’s existing curricula, the DALILA project has put special attention to this aspect, in order to make them experience the importance of a practical “know-how” during their studies.

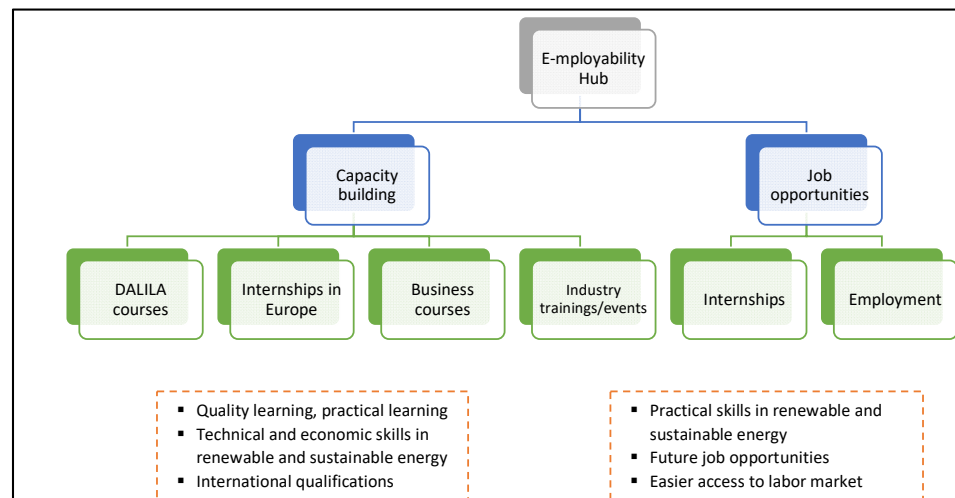


Figure 5. Main structure of the E-mployability hub.

5. Conclusions

The establishment of partnerships among several HEIs and local institutions to generate international programs focused on teaching renewable energy and green economics can be considered a strategy toward sustainability, sustainable development, and green energy transition. The goals of such endeavors are various: disseminating knowledge, creating, and enhancing an international network of HEIs committed to environmental education and engaging multiple stakeholders under the broad umbrella of sustainability. Thus, HEIs and the wider community benefit from these collaborative projects by increasing the sustainability and renewable energy awareness locally and internationally. The findings suggest that, in addition to cooperation, participation and collaboration, international teaching-oriented projects in HEIs have the potential to promulgate interdisciplinary approaches to address global sustainability and green transition challenges. In the description of the DALILA project implementation, the diverse arrays of disciplines and teams illustrate this point. In fact, as highlighted in the literature review, the implementation of interdisciplinary approach within the curricula in HEIs is important for the discussion and promotion of sustainability and sustainable development. In the DALILA project, the collaboration among HEIs and multi-stakeholders' approaches create an interdisciplinary environment for practical learning on renewable energy and green transition in local African contexts.

Climate change and the environmental crisis are complex topics that have dangerous effects at economic, social, cultural, political, and common health level in all Countries, mainly in those areas characterized by low development and poverty. Universities play a strategic role in growing public awareness on the problems connected with the climate issues and in the training of a generation of experts capable to approach problems providing solutions, designing alternatives, and suggesting suitable behaviors. In this sense, this paper offers a contribution in defining the role of universities for a green and sustainable transition in Uganda and Tanzania that can be integrated in the Special Issue of the journal about "Transformations for a Sustainable Future".

New didactic approaches pivoting on interdisciplinarity in renewable energy and green transition should be implemented in the curricula of economics and engineering faculties, to form adequate professionals able to cope with an ever-changing society. As a matter of a fact, a curriculum incorporating science, economy, business, and technology is the innovative aspect that DALILA is implementing, to support the education of a new generation of individuals. In general, a multidisciplinary approach is crucial to design a didactic product able to answer the real needs of a Country. In fact, the DALILA project aims at fostering cooperation, participation, and collaboration between European and African HEIs and local institutions, recognizing and valuing different kinds of knowledge, epistemologies, and cultures in renewable energy and green economy. Moreover,

in tackling the complexity of sustainable energies and green economy the courses proposed by the DALILA project tend to overcome the skill mismatches found in the local job market because: (i) academic disciplines are not in line with disciplines in demand on the labor market; (ii) curricula are outdated and their contents have limited relevance for an employment perspective and scarce emphasis on practical experience and soft skills; (iii) teaching and learning facilities and technologies are outdated. As the *ex ante* and *in itinere* evaluations have highlighted these issues, the DALILA project integrates programs that take into account digital content and innovative pedagogical approaches using technology, such as MOOCs and shared datasets of national and international reference literature among all the HEIs involved.

Ugandan education policy encourages the development of practical skills and entrepreneurship to support employability to foster the development of the private sector, by stimulating the establishment and growth of new enterprises. For the Uganda Martyrs University, the content and the pedagogies employed in the DALILA courses encourage the development of practical skills and the competencies of students to begin their own businesses. For the Uganda Christian University, the education sector in the country does not have a cross-discipline synergy in renewable energy and business. The University of Dodoma and the State University of Zanzibar in Tanzania also highlighted the importance of DALILA multi-disciplinary character. Technical and business courses will provide competencies in renewable technologies and soft skills in green business creation that are paramount aspects for employability. Such efforts may also foster opportunities for future research and joint projects. Sharing knowledge, experience, initiatives, and methods can hasten and deepen the research process, ultimately contributing to greater global impacts.

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