hUGe^2: An Interdisciplinary Research Program for Sustainability

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Abstract—**The continuous adoption and evolution of technology in all aspects and areas of our lives and our environment entails new and complex challenges and asks for interdisciplinary perspective to avoid biases that affect sustainable development. In today's digital, automated, and globally connected society, digitization and Artificial Intelligence (AI) are among the fields that are taking the most relevance attention and societal impacts. The new technological development they imply and their use by an increasing part of the world population demonstrate that they must be driven by and for all people in society (across gender, culture, nationality, and other kinds of discrimination), protecting and achieving a positive impact on the environment, as well as a sustainable economy for all. Although the challenge is evident, progress has been invariably slow and addressed from isolated perspectives. The hUGe^2 research program aims to address sustainability in and by technology (focusing on digitization and AI), analyzing from an interdisciplinary perspective the casuistry and existing discrimination (mainly due to gender imbalance, geographical inequalities, and lack of citizens' engagement), and proposing new ways to achieve the Sustainable Development Goals (SDGs) tackling the intersectional challenges. To do this, it will be centered around four PhD students and their supervisors, which will investigate common case studies and data sets from different scientific perspectives.**

Keywords—Sustainability, Gender Equality, Geography, Citizens, Digitalization

I. INTRODUCTION

According to Harari [1], technology (in particular, AI) and sustainability are among humanity's biggest challenges. A recent study [2] maps the relation between AI and the different SDGs established by the *United Nations* (UN) [3]. Sustainability is by nature a global challenge. The goal of fighting poverty and injustice, while safeguarding the environment for current and future generations, is the greatest challenge of our time and new knowledge is needed to tackle this complex challenge. Also, the effective participation of citizens in decision-making processes is currently hindered by barrier factors, among which a lack of suitable processes and tools for participation, knowledge on sustainable development, and awareness of participation opportunities [4]. At the *Norwegian University of Science and Technology* (NTNU), research on smart and sustainable development is a priority that includes environmental, economic, and social conditions, and active role of citizens in future city and society development (cf. https://www.ntnu.no/barekraft).

Regarding technology, software engineering [5] establishes new knowledge on key factors for the successful development of software systems, some of the most complex systems ever developed. From these, AI, digitalization, and other technology trends are changing how software is conceived, developed, and used [6]. Software pervades all aspects of society [7]. Links between software and sustainability have been explored and sustainability has been framed as a quality of software [8]. However, the focus has always been on the relation between technology and energy/climate neutrality (i.e., environmental sustainability) and marginally about the relation between technology and social and economic issues regarding sustainability [9].

As technology is increasingly used by the majority of the world's population, it must be driven by and for all people in society, avoiding gender, culture, nationality, and other kinds of discrimination. It is essential that all groups, including the most vulnerable and marginalized people, are included throughout the entire life cycle of a technology, i.e., from its conception, through its development and use, until it becomes obsolete. However, all over the world, women and other discriminated minorities (mainly for geographical reasons) are underrepresented in technology research, practice, and education. Although the problem is evident, progress to get around this situation is slow and scant [10], with results far from achieving sustainable development [11].

Specifically, gender imbalance in technology (known as digital gender gap) has been seen as harming the economy. The OECD (*Organization for Economic Co-operation and Development*) states that *"greater inclusion of women in the digital economy and increased diversity bring value, both social and economic"* [12]. In fact, the annual productivity loss for the European economy due to the digital gender gap is in a report by the *European Commission* estimated to 16.2 billion Euro [13]. Moreover, gender imbalance reduces the pool to harvest talents from and lack of diversity also makes for less innovative scientific outcomes [14]. And digital gender gap is seen to legitimize and support the hierarchical relations of men and women in society at large [15] [16]. So, an increased understanding of the interplay of technology and gender will benefit understanding of changes toward the achievement of a sustainable development through the SDGs.

The efforts performed by the UN through the "2030 Agenda" [3], establishing 17 goals and 169 targets to achieve sustainable development, are at risk of becoming a dead letter. We should not think only about the environment, but we have to address all the goals together and, especially, at a social and economic level, since a society without changes in itself will not generate any changes, innovations, and progresses. Likewise, it is equally important that all areas of knowledge start working together to achieve these goals, since without an interdisciplinary vision all development will be biased and isolated (as is often the case).

The novelty of the hUGe^2 research program is to investigate the interplay of gender perspective, geographic dimension, and citizens' engagement regarding technology (focusing on digitalization and AI), in order to design,

develop, implement, evaluate, and improve new and innovative tools, methods, practices, and processes for addressing and achieving environmental, social, and economic sustainability in and by technology, through a joint work and collaboration between different fields of knowledge.

The rest of this document is organized as follows: Section II contains the primary and secondary objectives, as well as the research questions established; Section III presents the methodology to be followed for the development of the research program; Section IV shows how the implementation of the research program will be conducted; Section V discusses the interdisciplinary potential of this proposal; and Section VI contains the conclusions reached.

II. RESEARCH OBJECTIVES

A. Primary Objective

hUGe^2 is an interdisciplinary research program aiming to design, develop, implement, evaluate, and improve new and innovative tools, methods, practices, and processes for addressing and achieving environmental, social, and economic sustainability in and by technology, by understanding and exposing a gender perspective, geographic dimension, and citizens' engagement regarding technology (focusing on AI and digitalization), through a joint research and collaboration between different areas of knowledge.

B. Secondary Objectives

From the beginning, hUGe^2 aims to (but is not limited to) primarily address the SDG 5 (Gender Equality), 10 (Reduce Inequalities), 11 (Sustainable Cities and Communities), and 17 (Partnership for the Goals), as shown in Fig. 1, to achieve sustainability considering the following objectives:

1. Understand and address major shifts in and by **technology** for sustainability, identifying the impact they have on it, as well as the ways that exist to achieve it considering the new technologies.

2. Understand and address the **gender** imbalance from the point of view of technology to identify and establish those aspects that must be considered to achieve a more inclusive and fair technology.

3. Understand and address **citizens'** engagement in sustainable regeneration processes to establish and apply a set of measures to empower them for sustainable practices in and by new technologies.

4. Understand and address **geographical** differences that affect egalitarian and inclusive processes in and by technology to propose new ways of understanding and collaboration that remove these barriers.

C. Research Questions

The following main research questions (RQ) will be considered:

- **RQ1.** How do major shifts in and by **technology** for sustainability take place, as well as how should new enabling technologies be developed, implemented, and adopted to achieve full sustainability?

- **RQ2.** How can technology be used to help achieving goals and targets related to enhancing **gender** equality, as well as which aspects and characteristics must be established in technology to make it more gender balanced?

- **RQ3.** How do **citizens** get engaged in the sustainable regeneration processes, as well as how in and by new technologies can increase their awareness and implication in these processes?

- **RQ4.** How do **geographical** differences affect egalitarian and inclusion processes in and by technology, as well as what can be done in and by technology to eliminate these geographical barriers?
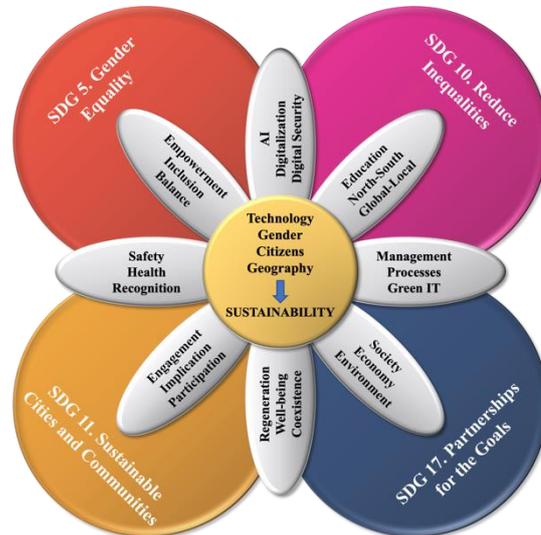

Fig. 1. Context of the hUGe^2 research program regarding the SDGs

III. METHODOLOGY

Novel process theories and artefacts will be developed by conducting a large number of design science studies [17] where interventions will be empirically validated through case studies [18]. We depend on access to cases in the industry and society as new theories and artefacts have implications which cannot be addressed in a controlled environment. The research data will be analyzed using several strategies as outlined by Langley [19]. Likewise, relevant research strategies will be considered and followed, including technical action research [20], systematic mapping study [21], focus group [22], among others, providing rigor and relevance.

The different research groups have already established cooperation with industry and public sector in Norway, Europe, and in the Global South, and some preliminary data sets are already available at project start.

Each PhD student will follow a research methodology that is initially built on the experience of the four investigators and that will be always refined during the project. Likewise, the activities and milestones established in the Table I must be addressed and achieved.

TABLE I. GENERAL ACTIVITIES AND MILESTONES

Activities and Milestones (MS)
- Conduct a *systematic mapping study* (MSX.1) in the areas of the RQ. (Year 1)
- Contribution to the common and interdisciplinary framework (MSX.2). (Years 1-2)
- Validation of the framework developed (MSX.3) through case studies in industry and society. (Years 2-3)
- Publish in top international venues (MSX.4), as well as collaborate and work with the rest of researchers in the hUGe^2 interdisciplinary research program. (Years 1-3)
- Thesis writing and dissertation (MSX.5). (Year 3)

IV. IMPLEMENTATION

A. Organization

The plan includes four interdisciplinary PhD students, who will be supervised by each of the research program supervisors. Each of these PhD students, belonging to different fields of knowledge, will focus on researching one of the established general RQs. In the same way, collaboration between the four PhD students will be constant, since each of the research needs to be nurtured by the rest to achieve the established objectives and to be able to adequately describe the different characteristics involved. Thus, all the results will be shared and the empirical case studies to validate the proposals will be conducted together.

The principal investigators have access to a set of case studies thorough existing projects [23] [24]. As a concrete example, the cooperation between NTNU, Yme (cf. https://www.yme.no/), and Leap Learning (cf. https://leaplearning.no/). Yme wishes to develop an app that can be a safe space for girls in developing countries to address the problem of circumcision. Leap Learning is developing such an app together with the research group led by Jaccheri based on the theories described in the SLR [25] and the results of an investigation that has been run in Norway about security and children [26].

B. Work Packages, Activities, and Milestones

This interdisciplinary research program consists of five work packages (WP). There is one WP for each of the established secondary objectives (which represent each of the RQs, as well as the PhD theses to be developed) and will follow the method developed in Section III (Methodology).

Of foremost importance, WP0 (see Table II) is related to the development of the interdisciplinarity of the project. This WP will not only deal with management and synchronization of supervisors, PhD students, and participating researchers, but will all the time question and define, where, among others, common research methods and set of measurements will also be developed.

TABLE II. WORK PACKAGE 0 – PROGRAM MANAGEMENT

WP0 – Interdisciplinary Research for Sustainability	
Main Goal	Primary objective of hUGe^2
Activities and Milestones (MS)	• Definition of an initial common and interdisciplinary framework including ethical issues and data management plan (MS0.1). (Year 0,5) • Synthesis of the four *systematic mapping studies* (MS0.2). (Year 1,5) • Validation of the common framework developed (MS0.3) through case studies in industry and society. (Years 2-3) • Definition of the top international venues (MS0.4). (Years 1-3) • Final event of the project (MS0.5). (Year 3)

V. INTERDISCIPLINARY POTENTIAL

The hUGe^2 research program is grounded at departments from different disciplines, since it is an interdisciplinary research that aims to cover technological, sociological, geographical, and environmental aspects. For this reason, collaboration between departments, supervisors, PhD students, and participating researchers will be constant, since the four streams of research will be developed in parallel and will nurture each other. In addition, interdisciplinary and joint scientific publications and public articles will also be performed, as well as joint attendance at national and international conferences, summer/winter schools, and local workshops and seminars.

In addition, thanks to the multiculturalism of the team and its groups and departments, as well as the relationships with renowned and relevant international researchers, centers, and institutions established through other projects, this research program will have a wide global network of active collaboration, through which research will be conducted on specific aspects where external actors are experts, as well as validations through case studies and research stays. Within this network, to name a few, are the 38 European countries, Asian countries (China, Bangladesh, Nepal, Vietnam...), American countries (USA, Canada, Mexico, Colombia...), etc.

VI. CONCLUSIONS

The hUGe^2 interdisciplinary research program will establish a basis for next generations of environmentally, socially, and economically friendly technologies and development processes in Norway and at international level. It will have a significant impact on the advance of technology and, especially, AI and digitalization regarding sustainability, as well as placing Norway at the international forefront by renewing best practices and technology process research for sustainability. It will also play an essential role to pave the way for Norwegian industry and NGOs (Non-Governmental Organizations) to participate in coming European partnerships for technology innovation for sustainability.

Likewise, those aspects related to sustainability that will be most positively impacted by this research program will be equality and inclusiveness both at the level of gender and of groups discriminated due to geographical reasons, as well as the engagement of citizens with sustainable regeneration processes. However, environmental and economic issues will also be addressed and will be impacted by the above, since the improvement of some leads to the advancement of others and at all times these perspectives will be considered, and measures will be proposed based on the findings obtained.

Finally, this program will build and disseminate knowledge on empirically and scientifically evaluated approaches through top international journals and conferences across the different fields of knowledge of the participating disciplines, attracting international researchers and professionals, as well as international research projects which will give Norway greater access to international knowledge production. In addition, the strong connections of the different participants with important partners and organizations in their sectors in Norway and different countries in Europe and around the world, will not only disseminate and empirically validate the research, but also become a world reference, creating the ground for continuation of the research beyond the program timeline.

Thus, the overarching aim of sustainability for this research program is to put the different groups and NTNU as the reference in Europe for innovation and research in Digitalization and AI for Sustainability from the Lenses of Gender Perspective, Geographical Dimension, and Citizens' Engagement.

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