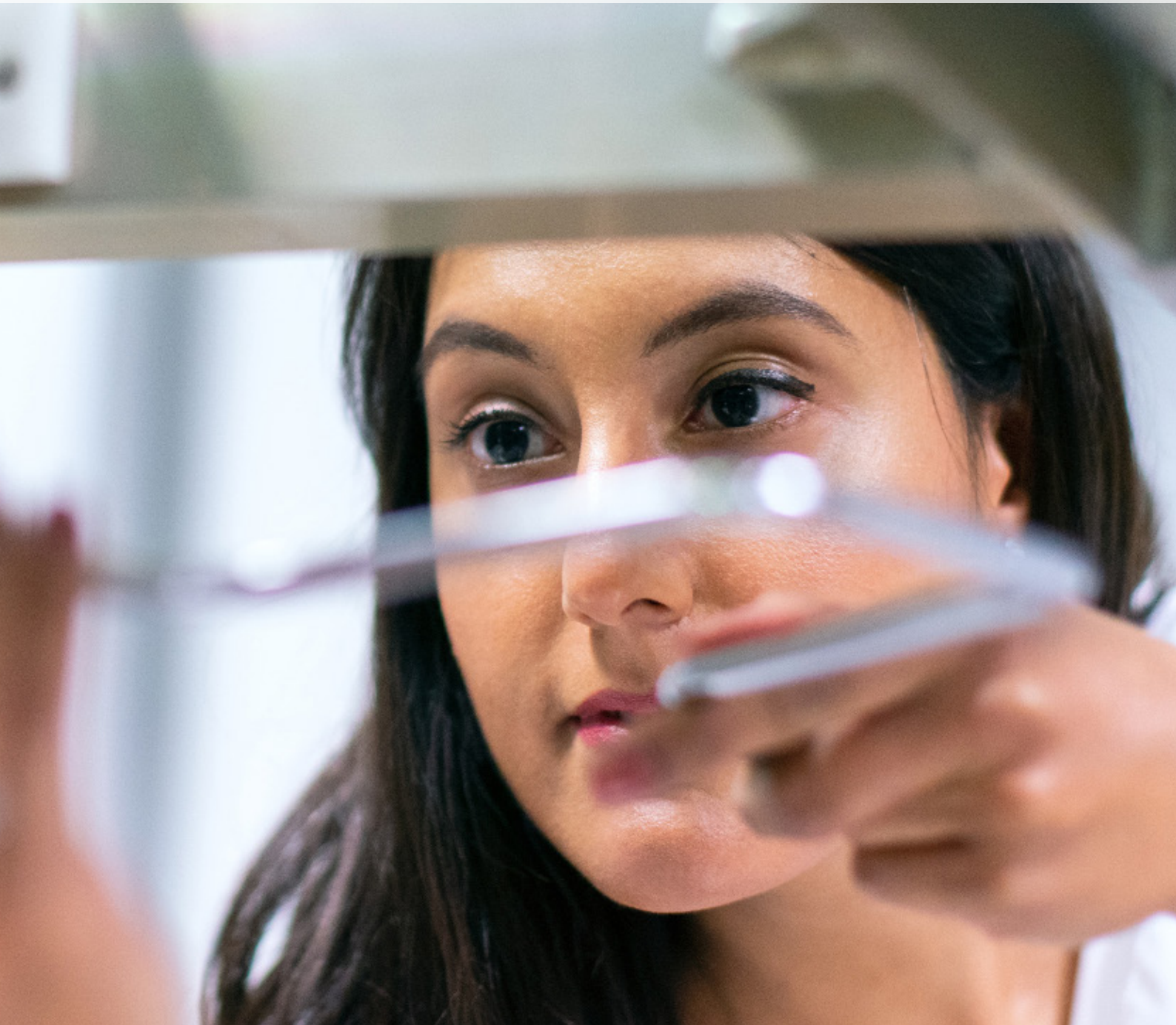
GenderInSITE

Gender in science, innovation, technology and engineering

Gender and Innovation: Implications for Sustainable Development

A GenderInSITE Policy Brief



Gender and Innovation: Implications for Sustainable Development
A GenderInSITE Policy Brief

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Published in November 2020
ISBN: 978-88-944054-1-5

Additional copies of this publication can be downloaded at:
https://genderinsite.net/sites/default/files/GenderInnovation.pdf.

* The author would like to thank the capable editing of Roseanne Diab and Peter McGrath and the comments of Shirley Malcom, Jennifer Thomson, Gloria Bonder, Miyoko Watanabe, Fang Xin, Phyllis Kalele, Antonel Olckers and Dong Wu.

About GenderInSITE

Gender in science, innovation, technology and engineering (GenderInSITE) is an international initiative to promote the role of women in science, innovation, technology and engineering. Its mission is to inspire transformative actions and more effective development by understanding the impacts of SITE on women and men and how women and men can contribute to SITE.

GenderInSITE builds partnerships among its members to identify, understand, and develop strategies to apply the gender lens to SITE in six key areas: agriculture and food security; water and sanitation; energy; transportation; climate change and disaster & risk reduction; and science education & the workforce. Its aim is to demonstrate that this can provide deeper insights, more effective programmes and more sustainable outcomes in the context of development.

It engages with networks of researchers and policy-makers, organizing awareness-raising activities and using dissemination tools and resources. Currently GenderInSITE has two regional focal points: in Africa, and in Latin America & the Caribbean.

GenderInSITE is supported by a financial contribution from the Swedish International Development Cooperation Agency (Sida) to the Organization for Women in Science for the Developing World (OWSD), hosted by The World Academy of Sciences (TWAS) in Trieste, Italy. Both TWAS and OWSD are considered programme units of UNESCO.

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Introduction

This policy brief considers the importance of applying a gender lens to innovation and sustainable development. It summarizes the key results of the workshop "Gender and Innovation: Implications for Sustainable Development", held in Pretoria, South Africa, in September 2017. The workshop´s main objectives were to understand and advance the complex road from science to innovation; to explore the differential impact that innovation has on the lives of men and women, especially in terms of new technologies introduced in development programs; to understand the needs of scientific research and education in science, technology, engineering and mathematics (STEM) to support the development of gendered innovation; and to discuss how to bridge the gap between knowledge of STEM and gender issues, and those who need access to this knowledge for policy- and decision-making for effective implementation of the Sustainable Development Goals (SDGs)[I]. Important outcomes of the workshop were that a gender perspective (1) leads to better research and innovation in support of sustainable development; (2) provides a basis for an inclusive approach that addresses all forms of inequality; and (3) provides a basis for linking all SDGs.

The value of these outcomes to the achievement of the SDGs in developing countries is underscored.In the last three decades, the way we look at gender equity and gender equality in science has changed radically; from viewing women as the main problem and suggesting initiatives that would enable individual women to attain the necessary qualifications to succeed in a scientific career to an understanding that diversity is central to scientific excellence and that institutional structural change is the only way of reaching gender equity in science. This shift in understanding is underpinned by a wealth of research and programs that have given us today a sound knowledge base as to how and why we should apply a gender lens to science and technology (S&T).

Some challenges remain, however, and one of them is the understanding of women´s role in science and innovation for development and how this role can be supported by using science, technology and innovation (STI). Over many years, a parallel debate has evolved about the importance of S&T for development, but for many decades this was a genderblind discussion. It was only at the beginning of the twenty-first century that international organizations started factoring in gender as an important issue and highlighting the economic implications of not using the full scientific potential of a country[II].

By focusing on innovation, the need for a gender lens, the importance of gendered innovations for sustainable development and their centrality to the attainment of the SDG targets, this policy brief aims at providing recommendations that are applicable to policy-makers in developing countries.

I The workshop proceedings (ASSAf, 2018), which captured in detail the presentations and discussions, is a basic reference for this brief. At the conclusion of the workshop, a small group of participants was approached to contribute to a proposed final report. Their contributions are acknowledged and have been taken into consideration and integrated into this policy brief (Comins *et al.*, 2017; Watanabe, 2017; Wu & Malcom, 2017).

II After the pioneer work of UNCSTD (1995) and UNESCO (2007), OECD (2012 and 2017), World Bank Group (2015), UNCTAD (2018) and World Bank and WTO (2020) have incorporated gender as a significant issue in their core strategies and actions.

Innovation

"Innovation – the creation and diffusion of new products, processes and methods – is an important driver of economic growth and provides crucial contributions to addressing societal challenges. In the global context, innovation draws on knowledge and concepts from across the world, though still often rooted in unique local and regional strengths" (Global Research Council, 2017, p.1).

There is today worldwide consensus and a vast international literature "*showing that innovation and entrepreneurship are central determinants of productivity growth and, consequently of long run development*" (Grazzi, 2018, p.98). In their policy brief on *The Imperative of Innovation*, the Organization for Economic Cooperation and Development (OECD) lists five action areas that will help governments foster more innovative, productive and prosperous societies, increase well-being, and strengthen the global economy in the process. These are: i) effective skill strategies; ii) open and competitive business environment; iii) sustained public investment in an efficient system of knowledge creation and diffusion; iv) increased access to and participation in the digital economy; and v) sound governance and implementation (OECD, 2015, p.12-13).

Effective skills and an efficient system of knowledge creation point to the intricate relationship between basic research and innovation. "*Within complex research and innovation ecosystems involving interactions between many stakeholders, the traditional concept of a linear innovation pipeline no longer applies. A renewed conceptualization of the relationship between discovery and innovation is as a dynamic interaction with numerous entry points and feedback loops, where information flow is multidirectional*" (Global Research Council, 2017, p.1).

Much of the literature on innovation and growth has been based on the experience of developed economies. Increasingly, however, the interest on how even the poorest countries can profit from innovation and entrepreneurship has grown. Different types and degrees of innovation can take place in different stages of development, classically identified as factor-driven, efficiency-driven and innovation-driven development. This is also related to different models of entrepreneurship as key economic actors, that in a developing country can range from subsidiaries of multinational firms, to privately owned firms, state-owned entities and individual entrepreneurs in small and medium sized enterprises and in the informal sector. How these actors relate to innovation has been the object of intensive study and analysis. A further important distinction is the one between incremental innovation and radical innovation, the latter linked to effective knowledge creation (UN University, 2011). Looking at the topic from a regional perspective, the Inter-American Development Bank (IADB) aptly describes the many faces of innovation as: "*the execution of a new way of doing things more efficiently (a more effective use of resources); a new or significantly improved product (good or service) or process; a new marketing practice; or a new organizational method in business practices, workplace organization, or external relations*" (Navarro *et al.*, 2016, p.17).

In all recent literature, one aspect highlighted with emphasis is the pivotal role of digital technologies to research and innovation. The unfolding digital revolution of recent years will profoundly impact the development of countries, since "*the adoption and use of digital technologies are key to transforming our productive sectors and business models*" (Navarro, 2017, p.3).

The need for a gender lens

For many years, the discussion on innovation has been devoid of any reference to gender. Only in the last decade has gender been addressed seriously. Indeed, a gender lens is essential if one wants to understand and reinforce innovation as a driver of development. Women are active agents of change in the use and application of technologies in many economic sectors, but in a way that may differ significantly from that of men. The variation in gender patterns between men and women in many areas must be considered if technology development is to better serve their specific needs and concerns. Examples abound, but hindsight shows how even the best-intentioned initiatives sometimes fail because women's perspectives and needs were not fully addressed (Zin, 2017, p.18).

We understand today that fixing the numbers, i.e. bringing more women to the S&T community, although important, does not necessarily result in structural transformation. As highlighted by Perkins (2018, p.22-24), women themselves may have different political agendas and make different choices about how they

see transformation and what is important for transformation. The implications for growing a culture of innovation that reflects an awareness of gender, and particularly the broader ambitions around gender and development, is a project that has a fundamentally social and political agenda.

How do we ensure that the gender lens is incorporated when developing innovations? Can men and women learn from each other? Are lenses absolute? Can we change the way we see things? Women are as important as men in contributing to development and they play central roles in sectors that affect well-being. STI are important in addressing challenges faced by women in fulfilling their roles as food producers, caregivers and social educators, and women can better understand STI-related issues that affect women. Educating women creates a scientifically literate society and contributes to industrial development.

The International Science, Technology, and Innovation Centre for South-South Cooperation (ISTIC) draws attention to the fact that women often hesitate to speak out because of a lack of confidence and education. Capacity building to provide women with communication, management, leadership, entrepreneurial and information and communication technology (ICT) skills can help them overcome this problem (Zin, 2018, p.18-22).

In its report *Applying a Gender Lens to STI*, the United Nations Conference on Trade and Development (UNCTAD) recommends three entry points for applying the gender lens: STI for women, women in science and women in innovation (UNCTAD, 2011 and 2017)). **STI for women** refers to the different ways that S&T recognizes women´s specific needs and brings improvements that can contribute to increased levels of income and enhanced quality of life for women and their families. Examples from different fields abound; studies in agricultural productivity and in access to water and energy, show that women and men have completely different relationships to these issues and that understanding their different needs brings more effective social and economic development. The Clean Cooking Global Alliance is a good example of innovation that recognizes the specific needs of women (see Box I).

BOX I

STI for Women

The Clean Cooking Alliance

Polluting open fires and inefficient stoves cause a range of harmful impacts, especially to women and children, that impede economic and social development and lead to significant loss of life in developing countries. Cleaner, more modern stoves, and fuel have the potential to reduce deaths from smoke-related illnesses, mitigate climate change and lower air pollution. They can provide new sources of livelihoods for women while reducing fuel collection and decreasing cooking fuel costs.

Established in 2010, the Clean Cooking Alliance works with a global network to build an inclusive industry that makes clean cooking accessible to the three billion people who live each day without it.

Their catalogue lists around 500 stoves and 700 test results, working with 14 different types of fuel, from biomass, to biogas and solar, as well as the more traditional coal, electricity and alcohol.

The alliance recognizes that women have critical roles to play across the entire clean cooking value chain and have developed many resources to empower women along that chain.

https://www.cleancookingalliance.org/about/

http://catalog.cleancookstoves.org/fuel-types

https://www.cleancookingalliance.org/impact-areas/women-gender/index.html

Box II

Women in Science

"*We have concluded that only a systemic approach will move us forward. We know of many things that work, but not at scale. We know of many things that work, but not for all groups. We know that institutions have barriers baked into their structures, but the nature of each institution's challenges is different. We know that institutions have to want to change, and that they can be incentivized through deployment of carrots and sticks. We know that funding agencies can play a major role in incentivizing change, and so too can the STEM and higher education communities themselves.*"

Written Testimony of Dr. Shirley Malcom, American Association for the Advancement of Science, before the Committee on Science, Space and Technology U.S. House of Representatives. May 9, 2019

The second entry point, **women in science**, is where more progress has been made (see Box II). The last thirty years have seen important developments in providing relevant and reliable sex disaggregated indicators in education, scientific careers, publications, wage gaps and work-life balance in several countries and regions, showing both the advancements and the persistent gaps in achieving a more equal balance between women and men in the scientific community[III]. The development of institutional programs and initiatives to implement gender equity have led to a greater perception of the obstacles and ingrained norms and rules that resist structural change in that direction[IV]. We have also learned that potential interventions can include: "gender sensitive policies related to life-work balance, flexible working conditions, professional development, exposure to women role models in STI, mentoring and, lastly, anti-discrimination regulations that can address recruitment, salary, and gender parity targets or quotas" (Wu & Malcom, 2017, p.2). There has been palpable progress in many of these areas, although the road to equity and equality is still a long one.

The third entry point, **women in innovation**, refers to the importance of encouraging and supporting the role of women in innovation systems at national and grassroots levels. However, in order to support

III See Caprile *et al.* (2012); European Commission (2002, 2004,2008); UNESCO (2018); Elsevier (2017, 2020).
IV Such as Advance and Sea Change programs in the USA, and Athena Swann in the UK.

women's participation in innovation one needs to understand their work patterns and needs.

Policy interventions focused on entrepreneurial development and innovation often overlook specific needs and issues faced by women's micro and small sized enterprises, particularly in the informal sector. To promote women in innovation, there is a need to provide advice, and training in expertise, experiences, and knowledge as a means to access markets, as well as to obtain the necessary financial support. Moreover, to encourage women's participation in businesses, representation at senior management levels is important, and this in turn requires knowledge of business and intellectual property rights management. The example of how an idea to grow vegetables in plastic bags has developed into a nationwide network in South Africa is a powerful example of how adequate support and guidance can transform an innovative idea into a marketable solution for many (see Box III). It shows that in developing countries, finding solutions that are innovative will require new mechanisms to determine real needs and priorities which will not be the sole responsibility of Government, or academia, or business and industry alone, but a joint effort which needs collaboration and facilitation. Indeed, it requires all these players to become acutely aware of the need for gender inclusion and to act upon this awareness (Comins *et al*., 2017, p.1-3).

BOX III

Women in Innovation

Umgibe: Growing vegetables in plastic bags

In rural areas in Africa, women are traditionally responsible for food production for family use, while men take responsibility for the cash crops. In an urban setting, however, especially in degraded areas, land for cultivation of vegetables is scarce, In 2014, facing the need to provide food for her family, a South African woman from KwaZulu-Natal decided to grow organic vegetables, but her efforts were destroyed by the chickens she raised in the same space. To solve this problem, she devised a system of vegetable growing using recycled plastic bags in a portable vertical structure. The system also solved the issues related to pesticide usage and uses a fraction of the water needed for conventional agriculture.

Today Umgibe Farming Organics and Training Institute is a nationwide network involved in: i) commercial vegetable production; ii) mobilization and capacitating of other agricultural co-operatives with the use of innovative and advanced agricultural techniques; iii) conducting commercial agriculture and food security workshops; and iv) building a network of partnerships. Currently, there are 34 cooperatives that are involved with Umgibe.

http://www.umgibe.org

The argument was made, taking South Africa as an example, that these efforts will need to span the wide diversity of needs across the whole population, and take more cognizance of both the needs of women in society (often in poor or rural areas), and also of their contribution to finding new solutions. This will never be a subject for governments alone, and the participation and investment of the private sector in R&D and innovation will need to be aligned to provide the necessary momentum to change (Comins *et al*., 2017, p. 3-6).

From invention to innovation: from research to entrepreneurship

BOX IV

From research to innovation

There is an intellectual and physical gap between research (linear thinking) and innovation (needs and market driven). Without a strong focus on problem identification, the likelihood of research meeting the need and leading to successful innovation is tenuous at best, and the linear model is basically flawed. Going from research and invention through to having an impact on the economy requires entrepreneurial behaviour. The innovation cycle is complicated, and research is not an isolated element but one part of a highly interconnected set of nodes. Connection with the other components is crucial. The problem with current practice is that even where there is alignment with a need, licensing out the intellectual property (IP) can break the bond between the research capacity and the end point where iterative connections are often required.

The road from fundamental research to innovation is a complex one (See Box IV). Innovation is not just invention, but rather the process of taking ideas right through to the market or application in society. Innovation must have consumers and markets and it must demonstrate an economic output or social impact. In the current era, innovations are often associated with new technology developments, but this is not a necessary condition as they could comprise old technology in novel settings. Innovation is strongly linked to business and industry or an end-user. In this context, there is a significant opportunity for women to play a greater role in bringing their perspective and experience to the innovation landscape, and this remains a greatly underutilized area (Comins *et al*., 2017, p.4). This complex network of relations from conception, research and implementation of innovations is illustrated in Figure 1. It shows that the stages are interconnected but non-linear, in that there may be frequent requirements to revert to new approaches and information in order to progress. Additionally, each stage requires much broader interactions and networks to achieve the required outputs. Many of the failures of efforts to innovate relate to an inability to appreciate that much additional work beyond 'research' is key.

Thus, the focus of developing countries' S&T policies should extend beyond academic research and focus equally on the other stages, stimulating entrepreneurial thinking and the understanding that the definition

stage of a problem and the required solution tends to generate knowledge while looking for an application. In particular, it needs to motivate all players to become acutely aware of the need for gender inclusion and to act upon this awareness (Comins *et al.*, 2017).

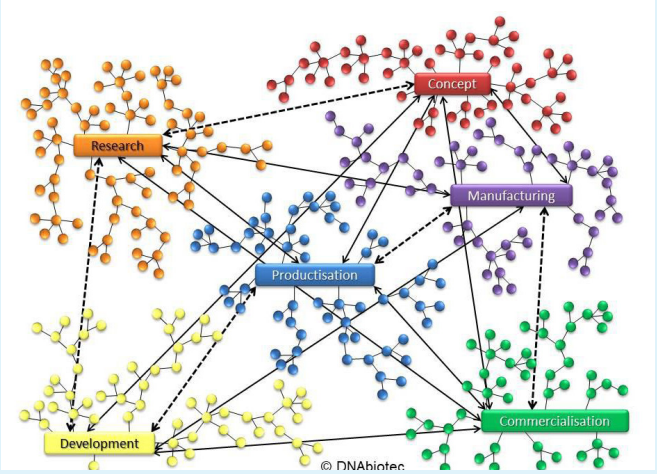

Figure 1. By kind permission of A. Olckers, DNAbiotec, 2012. Comins *et al.* (2017) p.4.

Today it is widely accepted that women's entrepreneurship is not only important to enhance women´s equality, empowerment and social inclusion, but also makes good economic sense[V]. Women are, however, still under-represented among entrepreneurs in many countries, and when they do become entrepreneurs, their enterprises are smaller, concentrated in fewer sectors and with less access to economic resources. Women tend to provide different solutions to management, organizational and business problems to those of men. Measuring women's entrepreneurial activity is critically important for a better understanding of how female entrepreneurs contribute to the economy and society. Evidence and Data for Gender Equality (EDGE), a multi-institutional project from the United Nations (UN), focused on entrepreneurship and asset ownership, and the World Bank Group are working to provide relevant indicators and databases to overcome this (World Bank, 2015). Entrepreneurial activity in the STEM fields is notably important for innovation and technological development and is key to driving women into non-traditional industries. A recent study by the IADB looks at women entrepreneurs in STEM in Latin America and the Caribbean and shows a significant improvement in high-impact women's entrepreneurship (United Nations, 2018; Meunier *et al.*, 2017; wX Insights, 2012).

Applying a gender lens to STI also ensures that policies are more effective, equitable and sustainable. Such an approach requires the mainstreaming of a gender perspective into the policy-making process, that is from policy formulation and agenda setting to design, implementation and impact evaluation (Wu & Malcom, 2017, p.3). The main message to be retained is that applying a gender lens in S&T can provide benefits for women, and increase their participation in science and innovation, as entrepreneurs benefiting from and adopting innovative technologies, notably ICTs.

Innovation and the role of ICTs

ICTs can provide information, learning and access to productive resources. They can also facilitate networking and entrepreneurship (ITU, 2016)[VI]. Thus, an important way to promote women's participation in innovation is the development of digital skills. ICTs are a critical issue when addressing the role of women in innovation (see Box V). There is a gender divide in access to and use of ICTs, as well as in access to the digital economy and representation in the sectors responsible for the information society. Women benefit less from the opportunities provided by ICTs and they have less of a voice since they are less "connected". The regional gender gap is largest in Africa (23%) and smallest in the Americas (2%). Enabling women's access to and control over ICTs is a key step for poverty alleviation and sustainable development. The gender gap in digital technologies and skills is one of the most persistent.

Two recent reports, Sey & Hafkin (2019)[VII] and UNESCO & EQUALS (2020), show that the digital skills gender gap is growing despite global efforts to include women and girls. This is true in relation to the general use of ICTs, but also in more advanced research areas such as mathematics and computing, where programming is seen very much as a male domain. The picture, however, is complex. There are large regional variations and interpreting the gaps requires careful and contextualized analysis. The barriers to gender digital equality are generally related to lack of infrastructure, financial constraints, ICT ability and aptitude, and socio-cultural and institutional contexts. Most of these barriers cut across issues of access, skills and leadership. Achieving gender equality in ICTs is not, therefore, an easy task. Many kinds of initiatives and actions will be needed.

V According to Woetzel *et al.* (2015), a "full-potential" scenario - in which women participate in the economy identically to men - would contribute as much as $28 trillion, or 26 percent, to annual global GDP by 2025.

VI The International Telecommunications Union (ITU) is the UN specialized agency for information and communication technologies (ICTs). https://www.itu.int/en/mediacentre/backgrounders/Pages/bridging-the-gender-divide.aspx and http://www.itu.int/en/ITU-D/Statistics/Pages/facts/default.aspx.

VII The report was published by the EQUALS Global Partnership for Gender Equality in the Digital Age, created in 2016, by the ITU, UN Women, the International Trade Centre, GSMA, and United Nations University.

BOX V

ICTs as inclusive Tools: A Persistent Gender Gap

Internet access and use of cell phones

In low- and middle-income countries (LMICs), about 2.9 billion people now access the internet on their mobile phones. In such countries, about 87 per cent of total broadband connections are made via a mobile device […]. But across LMICs, women are still eight per cent less likely than men to own a mobile phone, and 20 per cent less likely to use the internet on a mobile. This means that in these markets, 300 million fewer women than men use mobile internet. A key barrier is smartphone ownership, which is also 20 per cent lower for women than for men."

GSMA (2020)

Gender gap in ICT skills

"The gap is apparent from the lowest skill proficiency levels, such as using apps on a mobile phone, to the most advanced skills like coding computer software to support the analysis of large data sets. According to cross-national skills assessments, women in numerous countries are 25 per cent less likely than men to know how to leverage ICT for basic purposes, such as using simple arithmetic formulas in a spreadsheet." (p 15)

"At the most sophisticated end of the skill spectrum, women are less likely to create content or use cutting-edge technology. A recent survey of undergraduate students in 29 countries found that early adopters of new technologies are overwhelmingly male. Women are largely absent from the frontiers of technological innovation. At Google, 21 per cent of technical roles are filled by women, but only 10 per cent of their employees working on machine intelligence are female." (p 19)

Gendered innovations

The Gendered Innovations project goes to the core of how sex and gender in S&T have been considered over the last three decades (EU, 2013; Schiebinger & Klinge, 2010; Schiebinger & Schraudner, 2011; Schiebinger, 2018). The operative question for gendered innovations is whether the creative power of sex and gender analysis can be harnessed for discovery, and whether the consideration of gender adds a valuable dimension to research and takes research in a new direction. The answer is an emphatic yes: integrating sex and gender analysis into basic and applied research produces excellence in science, health and engineering research, policy, and practice. Equally important, bias against sex and gender leads to missed market opportunities, faulty results, and inefficiency.

Integrating sex and gender into research is a step further in the uphill battle of gender equity and gender equality in science. In the captivating shorthand description used in many of her presentations, Londa Schiebinger reminds us that governments, universities, and corporations have taken three strategic approaches to gender in science. The first two involve fixing the numbers (of women participating in science and engineering) and fixing the institutions (promoting structural changes in research organizations to advance gender equality in scientific careers). Although important and relevant, and still needing further progress, they should not be confused with fixing the knowledge (or gendered innovations, which stimulates excellence in STI by integrating sex and gender analysis into research).

Gendered Innovations is a project that was produced through a large international collaboration involving 80 basic (natural) scientists, engineers, and gender experts through funding from the European Commission, the National Science Foundation and Stanford University. The EC 2013 report *Gendered Innovations: How Gender Analysis contributes to Research* and the Gendered Innovations' website (https://genderedinnovations.stanford.edu) present information on about 30 case studies in which the integration of sex and gender into research creates excellence. The website also makes available many resources, such as methods for sex and gender analysis that were developed while working with the scientists and engineers.

The case studies on gendered innovations are compelling and sometimes surprising. Besides the well-known examples of how cardiovascular research greatly advanced when differences between women's and men's responses to a heart attack and to medication were recognized; and how crash test dummies based on male only models used in auto safety tests resulted in humans of different sex, size, shape and age being

BOX VI

Gendered Innovations

Rethinking concepts and theories: Public transportation

The innovative concept "mobility of care" provides a perspective for "recognizing care work" (Sánchez de Madariaga, 2009). Incorporating care work into user surveys identified the significant number of trips that men and women take for this purpose. [...] Understanding gender differences may render public transportation more responsive to users' needs, improve transportation research and policy, and has led to the concept of "trip chaining" that may have an impact in the design of public transport systems.

http://genderedinnovations.stanford.edu/case-studies/transportation.html

Analyzing gender: Machine translation (MT)

State-of-the-art translation systems overuse masculine pronouns (he, him) even where the text specifically refers to a woman (Minkov *et al.*, 2007). The result is an unacceptable infidelity of the resulting translations and perpetuation of gender bias. […] The reliance on a "masculine default" in modern machine translation systems results from current systems that do not determine the gender of each person mentioned in a text. Instead, the translation is produced by finding all the possible matches for a given phrase in large collections of bilingual texts, and then choosing a match based on factors such as its frequency in large text "corpora" (or bodies of text). Masculine pronouns are over-represented in the large text corpora that modern systems are trained on, resulting in over-use in translations. http://genderedinnovations.stanford.edu/case-studies/nlp.htm

Analysing sex: Stem cells

Biological sex is commonly studied as a variable in research with humans, but analysing sex is rare in animal research and rarer still in cell-based research (Beery & Zucker, 2011). This deficiency can represent a lost opportunity to understanding basic and developmental biology, and to refining cell-based therapies. […] Sex should be analysed at all levels, from chromosomes and cells to whole organisms. […] Research using animal models has shown that the sex of stem cells may influence therapeutically relevant cell traits, such as proliferation and differentiation rates.

https://genderedinnovations.stanford.edu/case-studies/stem_cells.html

more prone to harm in a car crash, Gendered Innovations is now analysing examples of machine translation, artificial intelligence (AI), stem cell treatment and climate change (see Box VI).

More importantly, in a powerful *Nature* article, *Sex and gender analysis improves science and engineering*, the authors identify the key actors involved in the process and show the way forward. "*Much work remains to be done to systematically integrate sex and gender analysis into relevant domains of science and technology—from strategic considerations for establishing research priorities to guidelines for establishing best practices in formulating research questions, designing methodologies and interpreting data. To make real progress in the next decade, researchers, funding agencies, peer-reviewed journals and universities need to coordinate efforts to develop and standardize methods of sex and gender analysis*" (Tannenbaum *et al.*, 2019, p.144).

Universities and networks of universities are pivotal for the integration of sex and gender in research. There is a huge amount of bias in academia, particularly in terms of recruitment and retention of students and staff, teaching and curriculum, knowledge production, and societal impact. Simone Buitendijk stated emphatically that "*Universities need to do a lot better to ensure that those from disadvantaged backgrounds are able to flourish and use their talents optimally. This can be done through thinking about the curriculum and teaching needs to be done differently, taking into account the realities of a diverse society and seeing students from different backgrounds as an asset rather than a problem. There needs to be much more awareness of diversity, inclusion, and equality*" (Buitendijk, 2018, p.11-12). (see Box VII)

BOX VII

Structural changes in universities to promote gender-aware knowledge production

Inclusive research and innovation at universities will attract a broader group of talented students, change the discussions and culture in the classroom, provide a diverse student body high-quality degrees and career options, attract and retain a broad group of researchers, stimulate institutional empathy, and create a multidisciplinary research environment with global societal impact.

Gendered/inclusive research and innovation must be promoted with urgency because global challenges cannot be resolved without inclusive knowledge production. Global change in knowledge production can be reached by putting gendered and inclusive research and innovation at the heart of the university strategy, challenging existing individual and institutional reward systems, and incentivizing inclusive research and teaching collaboration between universities globally.

Buitendijk (2018) p 11-12

Bias in knowledge production raises questions about what research is being done, who it is being done for, and how it can be used to better the world. It affects the core of what universities do, but, in particular, affects staff and students on an individual level, as well as the institutions in terms of culture, teaching, research and societal impact. Individual bias relates to gender, ethnicity, social status, disability, sexual orientation and age, and the intersections of these. At an institutional level, there is global bias with regard to the status of institutions and their rank in terms of world rankings, which are often related to geographical location and the field of research (Buitendijk, 2018).

Universities are also mentioned by Tannenbaum *et al.* (2019) as one of the three pillars of science infrastructure, together with funding agencies and peer-reviewed journals, that need to develop focused and coordinated policies to introduce sex and gender analysis in scientific research.

Up to now, however, the case studies of gendered innovations have been mainly based on developed countries' experiences. Even in countries with robust S&T systems the integration of sex and gender in research is far from being attained (Almeida, 2017). Good examples need to be found for the developing world. Although there are some interesting case studies from the South, for example, those published in three books produced as a collaboration between ISTIC and The World Academy of Sciences (TWAS) (ISTIC & TWAS, 2012, 2014, 2015), they do not have a gender perspective.

The compilation of examples from the global South should be, as with the previous case studies, the result of a multidisciplinary collaboration of experts from different countries and regions, showing how the introduction of the variables of sex and gender bring new perspectives and advance scientific knowledge. Exploring the specificities of the Amazon region, or island states, or desert regions, a gendered perspective to research will certainly bring new insights and knowledge that will enrich the understanding and analyses.

Gender, science and innovation and the SDGs

The adoption of the SDGs was the outcome of a long process that culminated in the adoption of a universal, integrated and transformative 2030 Agenda for Sustainable Development, along with a set of 17 SDGs and 169 associated targets, in September 2015. Since then, many specific initiatives and analyses have been produced to help countries to achieve the goals and targets by 2030, most of which recognize the relevance of STI to understanding and navigating relationships among social, environmental and economic development objectives.

The Technology Facilitation Mechanism (TFM) of the United Nations was established to facilitate "multi-stakeholder collaboration and partnerships through the sharing of information, experiences, best practices and policy advice among Member States, civil society, the private sector, the scientific community, UN entities and other stakeholders"[VIII]. The TFM has three components: i) A UN Interagency Task Team on Science, Technology and Innovation for the SDGs (IATT); ii) A collaborative multi-stakeholder Forum on Science, Technology and Innovation for the SDGs (STI Forum); and iii) An online platform as a gateway for information on existing STI initiatives, mechanisms and programs. In 2018, under the IATT, a Group on Gender and STI was formed with the purpose of increasing synergies and collaboration among the UN, its agencies, funds, and programs on issues pertaining to STI and gender. Its latest publication (in 2019) shows that gender and science initiatives are developed by 13 institutions of the United Nations. One of the latest products of this complex network of institutions and organizations is the 2020 Global Sustainable Development Report, *The Future is Now: Science for Achieving Sustainable Development* (United Nations, 2019).

Another important initiative is the Sustainable Development Solutions Network (SDSN) created by the UN in 2012 under the auspices of the UN Secretary General[IX]. The SDSN network spans six continents and has over 1,200 member institutions, many of them universities, arranged into 33 national and regional networks. It is responsible for a Sustainable Development Report (Sachs *et al*., 2020) and maintains the SDG Index and Dashboard, to assess progress towards the achievement of the SDGs at national and local levels. Since 2019, the SDSN hosts the Global Solutions Forum to showcase local initiatives to advance the SDGs. Its SDG Academy is a flagship education initiative, offering free online courses and MSc degrees in Sustainable Development and Development Practices. It also fosters research in specific SDG areas and coordinates The Thematic Research Network on Data and Statistics (TRENDS).

It is certainly reassuring that the last five years have seen some of the findings of the extensive gender and science research effort establish themselves firmly in official UN documents and reports. It is, however, necessary to recognize the initial efforts to position gender and science as a critical topic for the achievement of the SDGs and related targets.

The International Science Council (ISC), then known as ICSU, published its report, *Review of Targets for the Sustainable Development Goals: The Science Perspective*, (ICSU & ISSC, 2015) in early 2015, before the final UN negotiation. For ICSU, as the coordinator of one of the Major Groups at the UN, emphasizing science as central to the development of the SDGs was critical. Two years later ICSU revisited the adopted SDGs and targets with the report *A Guide to SDG Interactions: from Science to Implementation* (ICSU, 2017), to assist countries and policymakers to implement a full and comprehensive agenda for sustainable development. The report carefully identified categories of causal and functional relations underlying the progress of goals and targets, using a scale that indicates where one goal is inextricably linked to another to instances where progress on one target cancels progress on another. Although they had identified 78 scientific topics involving gender or women as the main or relevant concern in their 2015 report, the interaction of SDG5 with other SDGs was not fully exploited.

BOX VIII

Examples of sex and gender considerations in research topics leading to better results for specific SDGs

SDG 2: Zero Hunger - the targets include the special nutritional needs of adolescent girls, the role of women as food producers, and the importance of genetic diversity of seeds and plants. Their implementation could be enhanced through scientific understanding of sexual reproduction and maturation of plants and animals grown for food. Furthermore, such measures could also provide opportunities to enhance the role of women in aquaculture. Similarly, production of food crops that rely on animal pollination would benefit from measures building on sex-conscious research showing that availability of pollinators improves yields and quality of crops, thus requiring less land and fertilizer to produce the same results.

SDG 3: Good Health and Wellbeing - the scientific evidence showing how sex-gender differences impact on health outcomes is widely available, but many important issues still need investigation, such as the impact of adolescent pregnancy on maternal cognitive development, and the socioeconomic implications for these mothers, their families and society.

SDG 10: Reduced Inequalities - implementation measures will benefit from better understanding of how intra-household gender relationships control resource allocation, especially with regard to girls' education, their future, and their mothers' ability to participate in income-generating activities.

Lee and Pollitzer (2016) p 4-5

The close interrelation of gender with almost all of the SDGs was clearly spelled out in a report that followed the Gender Summit 5 -Asia Pacific held in 2015 in Seoul (Lee & Pollitzer, 2016 – see Box VIII), in which it was stated that the available scientific evidence shows that gender inequality "*cannot be separated from actions to tackle poverty, hunger, poor health and wellbeing, maternal death, climate change adaptation, energy and environmental burdens, economic hardships, and societal insecurity*". In the report, a group of experts identified 170 pieces of research evidence of how sex and gender are considered and integrated to give more effective results and understanding, as well as a similar number of research topics in need of further investigation.

Despite this increased recognition of gender equity

VIII See https://sustainabledevelopment.un.org/tfm.
IX https://www.unsdsn.org/.

as a central variable for all the SDGs, effective implementation of this perspective is still far from being realized. Actions and initiatives to achieve the goals and targets are developed at the country and local levels, and the many political, social, and economic factors stand as important barriers to effective implementation of gender equity programmes in S&T.

To advance the issue, the Gender Summit 10 – Asia Pacific, held in 2017 in Tokyo, suggested a new concept of Gender Equality 2.0 (GE2.0), in recognition that "gender equality" actions should also respect related sources of inequality within societies, such as age, sexuality, ability, religion, culture, ethnicity, race and geography. Taking this concept into consideration, gender difference is an important factor in R&D and plays an important role in achievement of the SDGs (Watanabe, 2017, p.2).

The Gender Summit 10 adopted three recommendations on gender equality as necessary conditions to accelerate and strengthen progress towards achieving the SDG targets: they were captured by the acronym BRIDGE, Better Research and Innovation through Diversity and Gender Equality (Watanabe, 2017, p.3):

1. Gender equality is an essential determinant of societal sustainability and well-being and affects how STI can improve people's lives. As such, gender equality provides a BRIDGE through which different SDG targets can be connected to thereby enhance implementation of all SDGs.
2. Gender equality should be a BRIDGE with STI and should be integrated into the implementation of all 17 SDGs. This can be achieved through interventions based on best scientific knowledge and technologies that recognize gender differences as an important factor in ensuring that solutions work effectively for all members of society, and are adopted by all stakeholders, including industry, as part of their own sustainability agendas.
3. Gender equality in the context of SDG targets must recognize the influence of human and societal diversity, and especially how societies define and BRIDGE the roles of and attitudes to women and girls.

The effective incorporation of this perspective clearly shows how all SDGs link with SDG5, indicating that a diversity concept that incorporates GE2.0 and gender difference is an important factor in R&D and plays a critical role in the achievement of all SDGs (Watanabe, 2017).

The way forward – recommendations for policymakers in developing countries

Innovation is a multidirectional process and in developing countries needs to be a joint effort of collaboration and facilitation, involving government, academia, the private sector, and society, where players should be acutely aware of the need for gender inclusion. One needs to be aware of both the needs of women in society and of their contribution to finding new solutions. The focus of innovation policies in developing countries should go beyond academic research and focus equally on the other stages, stimulating entrepreneurial thinking and the understanding that the definition stage of a problem and the required solution tends to generate knowledge looking for an application. In particular, it needs to motivate all players to become acutely aware of the need for gender inclusion and to act upon this awareness (Comins *et al.*, 2017).

Countries also need to recognize the importance of gendered innovations for sustainable development. The global agenda for sustainable development for the next few decades will be centred on the SDGs, but the effective fulfilment of their goals and targets needs a clear focus on gender. *Better research and innovation through diversity and gender equality* will lead to more effective results and understanding, as well as pointing to research topics in need of further investigation. Gendered Innovations add value to research by "*ensuring excellence and quality in outcomes and enhancing sustainability; adds value to society by making research more responsible to social needs and adds value to business by developing new ideas, patents and technology*" (European Commission, 2013). It is vital that developing countries establish a strong strategy to ensure a gender perspective in their policies and initiatives.

In response to these conclusions, a set of specific recommendations for Government, universities and funding agencies, particularly in the global South, are set out as follows:

- Promote the collection of gender-disaggregated data by all organizations to inform policy development.
- Consider gender as a core component of all development policies, programs, and actions.
- Promote the application of a gender lens in research.
- Acknowledge that the achievement of gender equality needs to focus on both men and women and not

just women and that it benefits society as a whole.

- Strive to close the gap between research and innovation by exposing researchers, particularly women, to entrepreneurial concepts that will encourage participation in innovation systems in both the formal and informal sectors and foster the development of small, medium and micro enterprises.
- Acknowledge that we lack information on the impact of gendered innovation in the economy, particularly in developing countries, and strive to document case studies of gendered innovations in the global South.
- Recognize that gender equality is an essential determinant of societal sustainability and well-being and affects how STI can improve people's lives.
- Integrate gender into the implementation of all 17 SDGs as was proposed at the Gender Summit Asia Pacific held in Seoul in 2015 to ensure more effective implementation. Gender inequality should not be separated from actions to tackle the SDGs focusing, for example, on poverty, hunger, health and wellbeing, education, climate change and energy and environmental sustainability.
- Embrace a shift from the notion of gender equality to inclusivity to ensure that all sources of inequality in society, including those based for example on age, religion, race, ethnicity, sexual diversity and geography, are considered. i.e. embrace the concept of GE2.0. An inclusive approach that embraces all forms of inequality is of particular importance to developing nations.

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