A GENDER SUMMIT® REPORT

Gender in science and innovation as component of inclusive socioeconomic growth

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Executive Summary

1. The purpose of this report is to show how and why scientific understanding of biological and sociocultural (sex-gender) differences between women and men can enhance success of innovation policies that seek to promote socioeconomic advancements through science and technology.

2. Historically, innovation policies have ignored the fact that societies and economies are deeply gendered. For instance, innovation strategies and programmes tend to assume equality in outcomes, i.e that what will work for men will work equally well for women, even though almost everywhere gender equality remains a goal rather than reality. They also tend to assume that science knowledge is gender neutral, i.e that it offers the same level of understanding for women and for men. But, in fact, male gender bias is common in scientific literature, and when biased knowledge is used as source of innovation ideas, the outcomes can be worse for women (or vice versa when the knowledge has female gender bias, as in breast cancer).

3. Discussions of innovation often omit to recognise that :

   - The quality of results may not be the same for women as for men when innovation ideas overlook the potential influence of sex-gender differences (biological, physical, behavioural).
   - The effectiveness of innovation process is dependent on who the actors and decisions makers are, and how information flows between them.
   - Trained and talented women are not sufficiently included in solving technological problems, and it is assumed that women are not interested in innovation.
   - The needs and preferences of women may be different to the needs and preferences of men, and are therefore worthy of special recognition.
   - The take-up of new products and services is dependent on gender-related cultural conditions and societal attitudes to technological change.

4. The report introduces the concept of **gendered innovation** and shows how it relates to innovation conceived as a process of *creating improvements over current practice, achieved through the exploitation of advances in knowledge, and resulting in new goods and services, and new ways of supplying existing goods and services*.

   This focus is different to the use of “gendered innovations” as a method for systematic analysis of sex-gender differences as primary research variables in scientific study design[1]. Furthermore, the main concern is about scientific, technological, and organisational relationships rather than other possible socioeconomic kinds of innvation such as new financial or marketing methods.

5. In the context of designing and implementing innovation strategies and programmes, the gendered innovation approach asks the following questions:

   - Will the resulting goods and services work equally well for women and for men?
   - Is current practice subject to explicit or implicit gender bias that causes or propagates socioeconomic or welfare inequalities between women and men?
   - Are the innovation goals based on science knowledge that itself contains gender bias, e.g. studies that assumed 'male' to be the norm, or have not disaggregated data by sex?
   - Did the analysis of potential market opportunities take into account the preferences, values, and behaviours of both women and men?
   - Were both women and men equally involved in innovation, i.e as problem solvers and decision makers?
   - Are there any cross cutting gender issues that are likely to influence the impact of the chosen innovation strategy or programme?

6. The specific motivation for this report is to respond to the OECD policy vision of *"Creating Our Common Future through Science and Technology"*, and to the OECD strategy of promoting *'inclusive innovation'*. The success of such policies can be greatly enhanced by making the design and implementation of the relevant innovation strategies and programmes sensitive to the different needs, values and behaviours of women and men, and the possibility that these differences may impact on the quality of outcomes.

7. The OECD inclusive innovation strategy[2] recognises that the poorest and most vulnerable groups in society have not benefited from economic progress. Women (and children) make up the largest proportion of this social category, which makes gendered innovation approach particularly pertinent. Furthermore, historically, the specific needs, preferences, and values of women (and children) have not been idenitfied as in need of specific discussion, apart of empowerment and human rights issues.

8. The gendered innovation approach helps identify and prevent gender bias in innovation programmes by paying equal attention to the needs of women and men. For example, when developing new services to improve maternal health of women living in remote geographic locations, it is essential to also include the role men, e.g. as husbands, fathers, carers, community leaders.

9. The gendered innovation approach described in this report involves analysis of the innovation process and goals using three gender dimensions: participation, outcomes and cross cutting impacts. Their potential influence can involve the following factors:

   - **Participation** is about how women and men are involved in the innovation process as decision makers and beneficiaries, because research shows that this can impact on creativity (e.g. better solution ideas), the efficiency of the process (better problem solving strategies), and take up of new technologies.
   - **Outcomes** are about how scientific advances are used to drive innovation ideas because great deal of science knowledge contains male gender bias created by historical tendency of research to rely on male subjects, and if used without questioning for innovation these biases will be replicated in the resulting products or services.

- **Cross cutting issues** are about recognising interrelated innovation opportunities that can lead to systemic improvements, for example, advancing sustainability by developing eco-friendly cleaning products that are free from chemicals harmful to women, target women as consumers, promote 'green' household consumer behaviour, and benefit the environment.

The connections between gendered innovation and inclusive innovation are demonstrated in the report through the example of the innovation programme of introducing improved cooking stoves in the Orissa region in India by showing how the three gender dimensions i.e. participation, outcomes, and cross cutting issues, interact with the OECD criteria of inclusive innovation, listed below[3]:

- Affordable access to goods and services
- Sustainability based on market mechanisms
- Quality of goods and services, and livelihood opportunities
- Access to the excluded populations
- Significant outreach.

10. The example of an innovation programme to improve maternal health in remote regions of Peru is used to show how gendered innovation can help identify possible cross cutting benefits when analysed through the lens of innovation ecosystem, which identifies all key actors who influence how knowledge is produced and utilised to achieve improvements.

11. The report shows that gender equality policies promoting empowerment of women and human rights cannot alone overcome consequences of gender bias arising from the scientific and technical knowledge used as driver for innovation strategies or programmes.

12. In October 2015, the OECD held Ministerial and stakeholder meeting in Daejeon, Republic of Korea, under the Creating Our Common Future Through Science and Technology[4] theme. The discussion focused on advancing innovation systems, and the conditions needed to:

- Improve the design and implementation of innovation strategies
- Improve impact of public investment in science and innovation
- Promote social responsibility of science policies in 21st century
- Promote science and innovation for health
- Create new technologies for a sustainable future and the green economy
- Promote science and innovation for global inclusiveness.

This report shows that gender issues should be part of these discussions.

13. The main conclusion of the report is that achieving socioeconomic growth **for all** requires recognition that the needs and preferences of women and men are often different and these differences are important for quality of innovation outcomes, but also that they can open up new markets for science knowledge.

Introduction

In the last 2–3 years, several important innovation policy agendas to address societal needs through science and technology have been proposed by major global players (e.g. OECD, United Nations, African Union, European Union). This report examines how gender fits into these aspirations, and in particular how it relates to the OECD agenda for "Creating Our Common Future through Science and Technology", and to the OECD strategy of 'inclusive innovation', as a way of bringing socioeconomic opportunities and benefits to the poorest and most vulnerable groups in society.

Raising awareness of gender issues in the context of science- and technology-led socioeconomic growth is important on three counts:

1. Societies and economies worldwide are gendered, i.e. historically men have benefited from socioeconomic advances much more than women. Despite increased participation in education globally, women continue to be prevented from realising opportunities as well as aspirations to pursue careers and labour market goals similar to those of men by societal and economic conditions that fail to provide effective means to reconcile family life and work at home with pursuing income generating work[5].

2. Science and technology are also gendered, i.e. there is widespread male gender bias in science knowledge and in technological innovations, both of which tend to prioritise the needs, values and preferences of men. This is exemplified by the history of innovation in speech recognition. The first speech recognition algorithms were developed in acoustic labs full of men and so were tested on men. But male voices, generally, have different frequency to women's voices, and, consequently, when speech recognition software products were first introduced to the market they worked well for men but not so well for women, and much of the then market opportunity was lost because the innovation process assumed users' needs to be 'gender neutral'.

3. Innovation systems, policies, strategies, and programmes in general assume a 'gender-neutral' perspective. For example, they may refer to 'user-centred' design, 'human scenarios', and observations of 'customer behaviour', but these neutral terms overlook a variety of important differences in the biological and physical characteristics and socio-culturally determined values, preferences and behaviours of women and men. Research evidence shows that these sex-gender differences can impact on the quality of innovation process and outcomes, and influence take-up of new products and services[6].

The focus of this report is on how outcomes of innovation can be improved for women and men through better understanding of sex-gender relationships and interactions. This perspective is different from the traditional gender concerns, which tend to focus on gender inequality and empowerment issues, specifically as experienced by women.

Environmental health is a good example. It involves biological, social and environmental drivers. Biological drivers determine differences in how female and male bodies respond to pollutants or toxic chemicals, and include interactions between body weight, fat-muscle composition, metabolic rates and pathways, and disposition by the body of harmful substances.

For instance, chronic exposure to copper can damage liver and kidneys — women show greater levels of copper in blood then men, and this has been linked to oral contraceptives

use[7]. Artificial fragrances, which are regularly added to domestic cleaning products, have been shown to affect women's health more than men's. Women spend more time on household chores than men and so are exposed to chemicals in cleaning products for longer time.

Figure 1 shows how sex-gender can influence the scope and quality of innovation process and outcomes. The three components are participation, i.e who is involved in decision making; knowledge, i.e the problems selected and how they are solved; and cross cutting benefits, i.e what other impacts can be created beyond solving the specific problem. In participation, for example, research shows that gender effects in team performance may differ depending if the team works in a gender-friendly or gender-hostile work cultures[8].

Figure 1 The dynamics of gender dimension relationships in design and implementation of innovation policies, strategies and programmes

Although this report focuses on the OECD strategy for 'inclusive innovation' and on the policy vision of "creating our common future through science and technology", the evidence and arguments presented apply equally to the African Union's Africa 2063 agenda, and to the United Nations' Sustainable Development Goals agenda[9]. These latter initiatives share the OECD'S commitment to promoting gender equality through empowerment and human rights, but all three adopt a gender-neutral position with regard to the role of science and technology, which should be challenged on the grounds that gender issues in science knowledge and in innovation can be addressed now, but the full empowerment of women in society will take long time[10].

Specifically, we already know that:

- Quality of innovation outcomes can be impaired when the scientific advances used as source of innovation ideas contain gender bias, i.e. the underlying research failed to consider impact of relevant sex-gender differences.[11]
- Efficiency and effectiveness of innovation ideas, processes, and solutions to problems can be enhanced by including more women in decision making (idea creation, problem solving, exploring market opportunities), on equal terms to men.[12]
- When innovations and market opportunities are pursued from a perspective focused on the values, preferences and behaviours of men only, it can have negative impact on acceptance and take up of new products, and promote rejection of technological change.[13]

Negative societal attitudes to innovation are reinforced by innovation practices that prioritise the engagement of men and the exclusion of women as innovation actors.[14] In the last 2–3 years, these gender issues have attracted attention of policy makers in Europe and have provoked changes in how the role of gender in research and innovation is perceived. In particular, the European Union's 8th Framework Programme for Research and Innovation, referred to as Horizon 2020, has adopted a more consistent approach to dealing with gender issues. Horizon 2020 has a budget of nearly 80 billion Euros over the period 2014–2020 and is expected to produce solutions to major societal challenges such as health, climate change, environmental issues, energy, and transport. It is an example of new clarity in understanding the role of gender in research and innovation. Specifically, Horizon 2020 identifies gender as a criterion of success to be achieved in three ways, namely by:

- Increasing the participation of women in scientific roles
- Increasing the proportion of proposals that integrate gender dimensions in research and innovation content, process and impact
- Increasing opportunities for the realisation of cross cutting benefits of gender sensitive and responsive measures.

Similarly oriented gender equality policies have been also advanced in Europe by national research funding bodies, with Nordic countries leading the way[15].

One important driver in promoting these attitudinal changes has been the scientific evidence showing that gender can impact on quality of research and innovation, which helped refocus attention from preoccupations with 'numbers' to preoccupations with knowledge making and application. The evidence shows, for example, that team performance can be improved through better gender balance and that the collective intelligence of a group increases when the number of women in the group increases (to approximately equal the number of men)[16]. Furthermore, analysis of inclusive and open approaches to innovation deploying 'crowd sourcing' techniques, as exemplified by www.innocentive.com, showed that female problem solvers from outside the formal science and technology establishments contributed the best solutions[17]. This newly emerging understanding of how gender impacts on group dynamics has expanded traditional social justice gender equality arguments to incorporate new arguments, based on empirical evidence, showing measurable performance benefits of engaging women in research and innovation.

Outside Horizon 2020, the efforts to advance gender equality in Europe also now include

stronger commitment to act achieved when in October 2015 all EU Member States signed the new Gender Action Plan 2016–2020 (GAP II)[18]. The Plan makes it mandatory to extend gender mainstreaming to all EU external relations, specifically with the following goals:

- Ensure girls' and women's physical and psychological integrity.
- Advance economic and social rights and empowerment of girls and women.
- Strengthen of girls' and women's voices, and participation.
- Create conditions within the EU institutions to effectively deliver these commitments.

The OECD agenda for "Creating Our Common Future Through Science and Technology": a gendered innovation perspective

The OECD's efforts to promote gender equality have, until now, focused largely on improving women's participation and leadership in governments, parliaments and judiciaries, but not in science and innovation contexts. If science and innovation are to be successfully deployed for socioeconomic advancement for all, gender equality issues specific to science and technology knowledge, practice, and culture must also be recognised and tackled.

In October 2015, the OECD held Ministerial and stakeholder meetings in Daejeon, Republic of Korea, convened under the Creating Our Common Future Through Science and Technology[19] theme. The discussion focused on innovation systems and the conditions needed to:

- Improve the design and implementation of innovation strategies.
- Improve impact of public investment in science and innovation.
- Promote social responsibility of science policies in 21st century.
- Promote science and innovation for health.
- Create new technologies for a sustainable future and the green economy.
- Promote science and innovation for global inclusiveness.

In Table 1 below, we provide evidence and examples of how gendered innovation fits into the sub-themes of the "our common future" vision.

OECD goals	Examples of gender related issues
Improve the design and implementation of innovation strategies	**"We need to ask the question: will the solution work equally well for women, will it work equally well for men: otherwise, we are wasting our time"** (*Peter Piot, co-discover of the Ebola virus*). The history of innovation is littered with ideas, technologies, and products that have prioritised the values, needs, and behaviours of men, and benefited men much more than women (e.g. car safety systems, drugs, ICTs, medical diagnostic and assistance, devices, insurance services). Past innovation strategies have regularly overlooked women as valid actors in innovation process, or as important consumers and potential markets for new products and services. By overlooking women, innovation policies have inadvertently promoted male gender attitudes to technology, which treat women's preferences and needs as less important than those of men and encourage the view that women are hostile to innovation[20]. This creates a 'self-fulfilling prophecy' whereby innovation strategies continue to treat women as less 'worthy' actors and targets for innovation. This is exemplified by the United Nations' 17 Sustainable Development Goals (SDGs)[21], where gender issues have been reduced to Goal 5 focused on improving empowerment and human rights for women and girls. However, when the 17 SDGs were analysed by 27 international gender experts, the results showed that implementation of each goal can benefit from being informed by scientific understanding of relevant biological and socio-cultural differences between women and men, and how these are intrinsically intertwined with poverty, hunger, health and wellbeing, maternal death, climate change adaptation, environment, and peaceful societies. The same views apply to the OECD's strategy of inclusive innovation[22].
Improve impact of public investment in science and innovation	**The value of public investment in science and innovation requires analysis of how it is allocated and what benefits it achieves for women as well as for men.** In general, impact of public investment in science and innovation is assessed from a gender-neutral position, even when there are clear gender equality implications, for instance creating differences in science employment (male bias in leadership positions) and in income generating opportunities of women and men (gender pay gap in academic system), or prioritising development of new products rather improving safety (for women) and sustainability of existing technologies(e.g. medical diagnostic devices). In many regions of the world, male bias dominates access and control over allocation of expenditures to education and healthcare, and to productive resources such as land and working capital[23]. In Europe, although more women than men are graduating from universities, and women's participation in labour markets is increasing (and with it their contribution to national taxes), this has not made any impact on how innovation strategies are designed and implemented. **For example, the size of the annual consumer budget worldwide in women's hands has been estimated to be equal to $ 28 trillion annually**[24].

OECD goals	Examples of gender related issues
	The growing economic capacity of women has been left out from analyses of impact of public investment in science and innovation event though it is relevant for: • Employment of women and men in science an innovation[25], and gender equality in pay • Working conditions so that women and men can fulfil their career aspiration • Recognition and deployment of women's scientific and innovation capital • Advancement towards knowledge-based economy through women's investment in their higher education.
Promote social responsibility of science policies in 21st century	**Gender effects play a critical role in how science can help address the main socioeconomic concerns of the 21st century, i.e climate change, renewable energy, food security, access to health and safe water, as well as societal wellbeing and security.** When the International Council for Science (ICSU) examined how the scientific community should participate in addressing societal challenges[26], they identified a number of conditions, including: the need for gender-related indicators of environmental impact assessment; natural-asset valuation; cost–benefit analysis and life-cycle costing; as well as collecting and analysing data on behaviour, values and beliefs. The scientific community is expected (but not obliged) to demonstrate social responsibility, and since, in this context, gender attitudes and beliefs influence social relationships and societal processes[27], gender issues should be included in discussions of social responsibility. For example, climate change is an area of great societal concern where gender issues have been marginalised until now. It is generally agreed that the socioeconomic impacts of climate change will affect the poor more severely than other groups in the population, and will exacerbate already present gender inequalities. This means that we can expect women to suffer more than men. These issues are intertwined with, but cannot be resolved only through the policy agendas focused on actions promoting socioeconomic transition towards a low-carbon development[28].
Promote science and innovation for health	**The provision of healthcare is universally considered as a matter of public good[29]. At the same time, extensive scientific evidence shows that sex-gender issues impact on efficacy of health measures. Therefore, adopting gender-sensitive approaches when designing and implementing health policies and measures is necessary to promote science and innovation for health**. For example, the policy to make drugs more accessible to the poor should be informed by research showing that adverse drug reactions (which in the USA alone affect 4.3 million people annually) occur twice as often in women as in men[30]. And, policies promoting immunization programmes should take into account knowledge of sex differences in physiological responses of women and men, with women's bodies mounting stronger antibody response than the bodies of men, which has led researchers to suggest reduction in dosage for women that could, in turn, make more vaccine available for other vulnerable groups[31.] The scientific understanding of toxicity of drugs is based on studies that have mainly used male animals as subjects[32]. Most medicines have not been tested on women[33], and this can lead to worse effects drugs can produce in women than in men[34]. The consequences of gender bias in health policy are well demonstrated through health policies involving vaccination for Human Papilloma Virus (HPV). Each year, >500,000 individuals are diagnosed worldwide with HPV associated cancers. Better understanding of HPV biology has permitted major advances in the development of prophylactic vaccines and in the detection of HPV-associated diseases. Some countries only vaccinate girls but when all the economic costs of dealing with HPV diseases are considered, these calculations strongly recommend a vaccination strategy that includes boys as well[35].
Create new technologies for a sustainable future and the green economy	Green technologies should promotes sustainable patterns of production and consumption, i.e conditions that bring quality of life to women and men as consumers, and are resource- and energy-efficient, low-carbon, low-waste, non-polluting, and safe, and which manufacture products that are responsibly managed through their lifecycles. **Green economy should be considered from the perspective of impact on human interactions with natural ecosystems in which women and men often play different roles but whose livelihoods depend on ensuring sustainability of natural ecosystem services**. For example, marine ecosystems can be the source of several services essential to socioeconomic activities such as: (1) fishing; (2) coastal agriculture; (3) mining of sea minerals; (4) land reclamation; (5) coastal development and urbanization; (6) tourism and recreation. Overuse or exclusion from accessing these services can increase vulnerability of people to poverty and food insecurity. These problems (which can be classified into economic, social, institutional and biological) are responsible for the alarming increase in illegal fishing activities by small-scale fishers. The illegal fishing practices range from the use of explosives and poisons to the use of highly destructive fishing gears, methods and technique[36]. It is the women of the households who must shoulder the burden of these men's care and who must increase their own income-earning activities to replace the lost income previously earned by these men when accidents happen.

OECD goals	Examples of gender related issues
	Scientific understanding of human-natural ecosystems interactions also includes the role of sex , e.g. as in reproduction, in non-human species. For example, the demand for fish as food is increasing[37]and understanding sexual reproduction in fish can contribute to more effective farming of fish to meet growing demand, and protect stocks of wild fish. By this, it can also help protect marine biodiversity. Technologies that utilize understanding of basic reproductive biology of fish, which show why and how in certain species it is the male that grows faster and in others it is the female, can help increase supply of fish for the expanding population, and reduce stress on the already depleted coastal and inshore fishery resources in many regions.
Promote science and innovation for global inclusiveness	**The assessment of women's current socioeconomic status[38] shows that most countries have failed to include women to an equal extent to men in the knowledge economy.** Globalization and increasing competition favour technology-intensive production and skilled labour, which favour the employment of men. Women have been side-lined in economic diversification opportunities. There are universal barriers to inclusiveness that also apply to science. For example, UNIDO has identified the following global conditions that exclude women from opportunities to improved their status in society and economy[39]: • Low participation in leadership and decision making positions • Gender discriminatory local, state, federal laws and statutes, regulations, standards and rights • Lack of gender-sensitive public sector spending, including a lack of gender budgeting and audits • Low levels of affirmative action and quota policies for participation of women in national and state level science and technology endeavours • Low levels of public expenditure in areas of need that impact women in particular, such as health-care, science education and training, child-care, and essential infrastructures such as safe water and transport • Gender-blind industrial policies, including low levels of industry competence and political will to work on gender issues • Lack of recognition of women's 'reproductive' / unpaid work • Bias in labour policies that dictate gender differentials in earnings and organization of work • Low levels of women's participation in leadership and decision-making in research, innovation, development • Technologies designed by and for men, which are not always appropriate or accessible by women • Gender blind data collection without sex disaggregated analysis

Designing and implementing gendered innovation strategies and programmes

> Innovation is a collective activity. It takes place within the context of a wider system, 'the innovation system', in which technology and information flows among people, enterprises and institutions. This flow is key to an innovative process. It stresses the interaction between actors who are needed in order to create good ideas and turn them into a successful process and a useful product or service in the marketplace.

Box 1 - Defining innovation

The above definition of innovation stresses the collective nature of innovation systems, which depend on efficient flows of information between different actors. Gendered innovation adds a new perspective by questioning who these actors should be, how do they interact, communicate, and make decisions, what kind of scientific advances are prioritised, and how this information is exchanged in the process of innovation idea creation, adaptation, translation and transformation into (useful) products or services.

Gendered innovation recognises that scientific advances may contain gender bias because historically studies used males as research subjects, and often researchers failed to disaggregate data and results by sex, or adopted neutral terms such as "patient", "user", "household" when analysing and communicating results. Consequently, the 'male as the norm' assumption dominates science knowledge today. It means that science has more evidence for men than for women[40]. This male bias in science knowledge can result in innovation outcomes that are poorer for women (e.g. treatment of cardiovascular diseases[41], cancer screening[42], drug toxicity[43], vaccination efficacy[44], car safety systems[45], stem cells for regenerative medicine[46], medical diagnostic devices[47]). Therefore, scientific advances applied for the purpose of innovation should be systematically scrutinised for possible male (or female) gender bias[48].

Gendered innovation also recognises that innovation methods may be 'gender blind' or biased, when the aim is to understand 'customer' needs; create 'user-centred' design; identify 'human-centred' scenarios of use; observe 'user behaviour'; enhance collaboration in 'teams' without considering that women's contributions and needs may not be the same as those of men[49]. For example, the "user-centred" approach rarely asks if the design should be different for women and men, and ethnographic studies often end up consulting and observing men, but not women. Significantly, this promotes the view in society that women are "hostile to innovation" and that the most innovation-friendly group in society are young, well-educated men. Consequently, innovation strategies tend to ignore:

- The importance of assessing possible impact of sex-gender differences on outcomes.
- Availability of female intellectual and creative talent
- The benefits of involving different problem solving and leadership styles, which women can bring into the process.
- Opportunities for new knowledge applications, and for creating new markets based on new scientific understanding of sex-gender difference effects.
- The influence of negative gender attitudes on resistance to technological change.

Gender relationships and dynamics in innovation goals and processes

Gendered innovation examines innovation goals and processes from three interconnected perspectives:

1. Gender relationships in **participation**, because women and men bring different knowledge, experiences, cognitive styles, values, preferences and behaviours into innovation process, which influence choices and decisions. For example, gender balance in a team increases collective intelligence of the team[51] by improving communication and social sensitivity in how members of the groups interact. Research also shows that gender balance diversifies problem-solving styles, and prevents over- or under-estimation of risk.[52,53]

2. Sex-gender difference relationships in **outcomes**, because quality of results can be negatively influenced by gender bias in scientific knowledge, for example when scientific results are based on data for males only but results of the innovation are intended for women and men[54]. For instance, vaccination researchers have historically assumed that any side effects will be the same for women and men, but recent studies have shown this to be wrong by demonstrating that women's immune response to vaccination is often stronger than that of men, and involves different biochemical pathways[55], and, in fact, women may need lower dosage compared to men. This has consequences for public health strategy to protect populations from infectious diseases.

3. **Cross cutting** sex-gender relationships because a solution to one problem may interact with other, related problems and when considered together can produce system-level benefits. For example, food security is a key challenge for many societies in the world and fish farming provides one of the answers how protein rich food can be produced. Applying the gendered innovation concept helps exploit scientific knowledge of sexual maturation of fish, which shows that in some species it is the female that grows faster and in others it is the male, to improve management of aquacultures. This can be combined with training women to participate in aquaculture value chains, to improve their income generating opportunities. The added value is women's and community empowerment. Scientific knowledge of sexual reproduction of fish can be used for innovations to protect marine biodiversity. Lastly, encouraging a diet based on fish promotes nutritional health of women and children, and of the community.[56]

Gender relationships and dynamics in participation, outcomes and cross cutting conditions are closely related to the OECD's criteria of inclusive innovation, i.e creating products and services that are affordable, accessible, sustainable, quality, and offer significant outreach. We show this in Table 2 by analysing the innovation programme to introduce improved cooking stoves in the Orissa region in India, one of the poorest in the country. In many low-income countries households often do not have a choice of cooking fuels and must rely on biomass fuel. The inhalation of smoke produced by these methods during cooking can have serious health consequences, and women and children are particularly affected. Research shows that the simple solution of improving ventilation by increasing the permeability of roofs or walls has no significant effect on improving health, and that it is stove chimneys, but not windows, that help mitigate the health consequences of cooking with biomass fuels[57]. The aim of the innovation programme in Orissa was to reduce health problems associated with exposure to internal pollution created by traditional stoves, and to reduce the amount of biofuel used for cooking. The discussion in Table 2 is based on a study by researchers at Harvard University who followed the implementation of the programme over a period of four years.[58]

Orissa is one of the poorest states in India with 40 % of the population living below the poverty line. The objective of the Orissa programme (shared by similar programmes elsewhere, e.g. in Peru and Ghana) was to achieve two critical improvements:

- Better health by reducing inhalation of smoke: According to the World Health Organisation around 3 billion people cook and heat their homes using open fires and simple stoves burning biomass (wood, animal dung and crop waste) and coal. Over 4 million people die prematurely from illness attributable to the household air pollution from cooking with solid fuels."Women and children are particularly at health risk from exposure to the hazardous chemicals.
- Combat climate change by reducing the amount of fuel used: In September 2010, Hillary Clinton announced the formation of the Global Alliance for Clean Cook Stoves (GACC), which calls for 100 million homes to adopt clean and efficient stoves and fuels by 2020.

By achieving less time spent on collecting wood (traditionally done by women), shorter cooking time, and less fuel used, the improved cooking stoves also offered important opportunities to achieve gender sensitive socioeconomic improvements.

The intentions and the design of the programme complies with the OECD criteria for an inclusive innovation project:

- Affordable access: the chosen stove can be easily constructed in the remote, rural areas of India, and cost roughly US$12.50 to make but because installation is heavily subsidized, households only pay 75 cents
- Sustainability: the improved cook stove promised three important improvements: saving on amount of fuel used, saving on time taken to collect fuel, and shorter cooking time
- Quality of goods: the stove was designed to be made from locally available materials and easily constructed in remote, rural areas
- Access to excluded population: 96% of primary cooks are women
- Significant outreach: billions of people worldwide rely on open fires for home cooked meals

Nonetheless, the programme failed to achieve the two key objectives, namely improved health and reduced energy use because after a little while households returned to using traditional stoves. Applying the gendered innovation perspective helps explain why the uptake of the improved ovens was so much lower than hoped for.

- **Participation**: the stoves implemented in Orissa were designed and tested in laboratory conditions. Under these conditions they did offer significant improvements over traditional stoves. However, the design process did not involve consulting the actual target users (96% of whom are women). Consequently, important gender issues relating to the use and maintenance of the ovens were overlooked. Traditionally, it is men and not women who are responsible for household structural repairs. The new stove needed investment in the effort to keep it in good working conditions, or repair it when needed fixing, which, it was assumed, the "household" will do. However, if looking after a cooking stove was not considered to be a man's job, and if men spent most of their time working in the fields, repairing the new stove was not their priority since the cooking of meals could continue with the traditional stoves.
- **Outcomes**: As the new stoves deteriorated, "households" (i.e the women) reverted to using traditional stoves. In addition, households with the improved stoves were experiencing a modest decline in living standards as they devoted time and effort to upkeep of the stoves.
- **Cross cutting issues**: The possible cross cutting benefits could have been: improved health, less fuel used, shorter cooking times, less time spent on gathering fuel, less money spent on fuel, more time for income generating activities, contribution to the reduction of greenhouse gas emissions. However, although the Harvard study identified self-reported improvement in health and cooking time, this was not confirmed when assessed against objective criteria. There was no decrease in the amount of wood used and therefore no reduction in greenhouse gas emissions as anticipated.

Table 2 Gender relationship dynamics in the improved cooking stoves innovation programme in the Orissa region of India

Gender as driver for innovation sustainability

The OECD has identified consumer behaviour as a key target for developing growth strategies that promote greener lifestyles[59]. Gendered innovation can help achieve this goal. For example, routinely used household cleaning products are the second biggest environmental concern in the USA (after cars).

A life-cycle assessments by Proctor and Gamble to calculate the amount of energy needed to use their products found that 3% of consumers annual electricity budgets in the USA was spent on heating water for washing clothes. Switching to cold-water washing would consume 80 billion fewer kilowatt-hours of electricity and emit 34 million fewer tons of carbon dioxide[60]. But there are other reasons why innovations targeting cleaning products should take women into account:

- Women are the biggest users of cleaning products
- Women decide which household cleaning products are purchased
- It has been estimated that globally women control around $28 trillion in annual consumer spending[61]
- Cleaning products are heavily scented and women experience more frequent allergies to fragrances used in washing and cleaning agents, which is linked to the women's greater time spent on doing laundry, cleaning and washing dishes[62]
- In 2010, the Industry Fragrance Association (IFRA) has published a list of 2947 materials used in fragrance products, including those used in cleaning products but the IFRA safety standards apply to only 191 of these materials[63]
- Replacing synthetic fragrance with naturally produced ones could provide an opportunity for empowering women farmers in developing world by providing them with income generating opportunities involving growing and processing flowers for the production of safe fragrances
- Removal of synthetic chemicals used in the production of fragrance will contribute to improved environmental health, and protect natural ecosystems.

A poignant example of how the gendered innovation approach can improve opportunities for developing innovation programmes that promote sustainability is provided by the case of menstrual hygiene, an issue that has many repercussions specific to women in terms of their health, but involves also physical conditions and cultural beliefs that often restrict what women can do during menstruation. It is common practice in many societies, for example, to exclude women from social activities, including girls attending school, during these periods, which disrupts their lives and that of their families[64].

One of the examples used by the OECD to demonstrate inclusive innovation involves the development of a sanitary napkin machine by the Jayaashree Industries[65]. Box 2 below provides some insight into how this product was created, and how women were invloved in the innovation process and influenced the design[66].

"While designing his machine, A. Muruganandam incorporated localized content and feedback, thus making the final product more conducive to the average woman. He realized that women are often ashamed, shy or embarrassed to candidly discuss about their menstrual problems, even to other women. So, he developed questionnaires and conducted trial methods by distributing his preliminary napkin samples to female university students at local medical universities in Tamil Nadu. The collection of samples and feedback was done via female medical students, who reported the data back to him. He then studied the used napkin samples to test for absorbability and conduciveness to women of different sizes. Thus, Murungnandam was respectful and aware of constraints of the local culture, which were deeply embedded in the planning, designing, and implementation of this product. After the successful launch of this machine, he became the founder of Jayaashree Industries, through which he started delivering his machine and napkins to local women".

Box 2 Involving women in the design of sanitary napkins

The Jayaashree example shows that allowing women to actively participate in the innovation process helps improve the design of the product, but also that such participation achieves empowerment by giving women:

- A sense of self-worth
- The right to have and determine choices
- The right to have access to opportunities and resources
- The right to have the power to control their own lives, both within and outside the home
- The ability to influence the direction of social change[67].

This is an important condition for achieving sustainable economies and societal wellbeing[68,69]. Examined from a gendered innovation perspective, innovations leading to improvements in current menstrual hygiene practice can help achieve wide variety of cross cutting benefits, such as:

- New information services for better communication and awareness raising to improve understanding of menstrual hygiene issues among adolescent girls and boys, and women and men.
- Policy innovations that empower women by protecting them from social practices like seclusion, absenteeism, religious or social exclusion.
- Technological innovations through products enabling women to more fully participate in income generating activities and prevent girls dropping-out from education at puberty, due to poor sanitation facilities, and restrictions on mobility.
- Health products innovation to address related medical issues - rashes and infections.
- Scientific and technological advancements leading to affordable, cost efficient, biodegradable, easily accessible and social acceptable materials.
- Improved practices and equipment for better ways of washing and drying of cloths.
- Scientific and technological advancements for effective ways to dispose or recycle used napkins, cloths, and to manage waste.

Gender dynamics in innovation ecosystems

The concept of innovation ecosystem is helpful when exploring sex-gender issues as sources of cross cutting impacts. In Figure 2, we show how gender fits into:

- Knowledge production, application and communication
- Innovation and technological advances
- Creation of markets for new products/services.

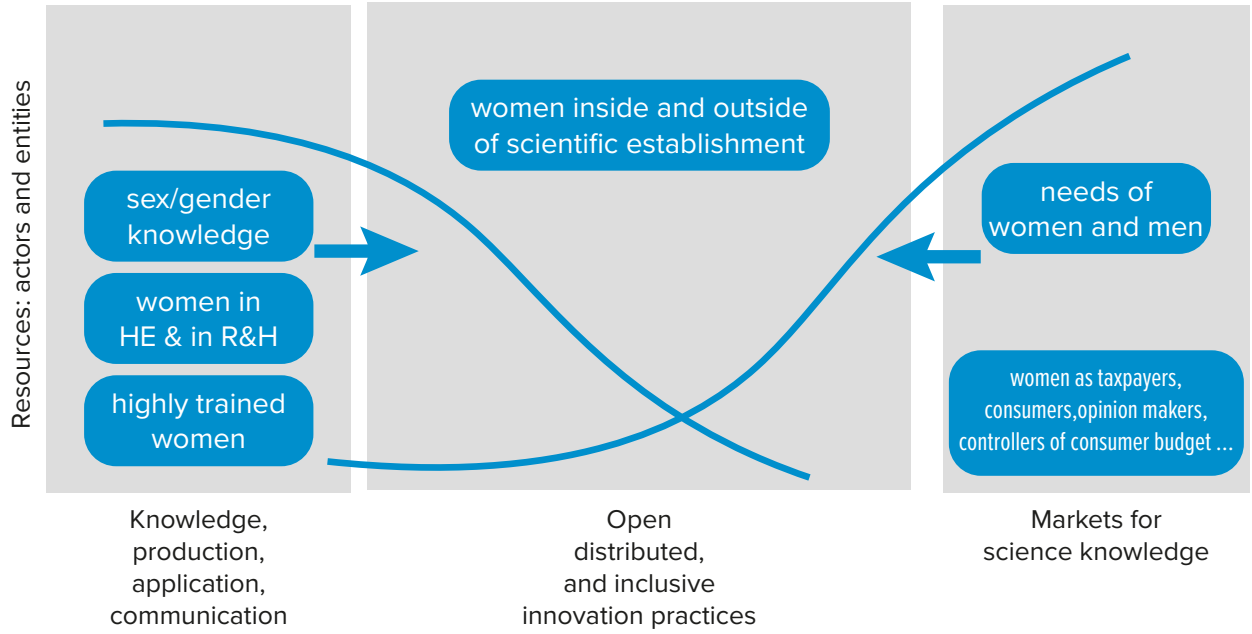

Figure 2 Model of gendered innovation ecosystem

In principle, innovation ecosystems can be created around any topic. So, for example, with the potential market of 50% of global population, it is possible to conceive a gendered innovation ecosystem developed around the menstrual hygiene problem.

But, we use the example of Mama River Programme developed in Peru[70] to show how sex-gender issues can influence the scope and impact of innovations that depend on scientific and technological advances and societal relationships. The original aims of the Mama River Programme are summarised in Box 3.

The main goal is to develop innovative services for protecting maternal and baby health during pregnancy in the regions of Peru where access to health services is made difficult by the remoteness of the locations where the women and babies live. It is an example of socio-technical innovation that offers a variety of important cross cutting benefits, one of which is that it enables a baby born in the remote areas of Peru to be recorded in the national citizen information system and, thus, receive formal identity that is necessary for accessing governmental social services.

The programme trains community agents (traditional midwives, health promoters and community mobilizers) to use smartphones to:

- Geo-reference and collect basic information from pregnant women at their communities, and send this information to a Medical Ship in order to program antenatal care visits;
- Send alerts to the medical ships whenever a high-risk pregnancy is identified; and
- Send reports of live childbirths (for the issue of national ID cards that grant access to governmental social services) or deaths.

This is achieved by providing the community agents with the Mama River Kit that includes:

- Communication devices such as a smart phone (with the ODK application that was used for reporting health data) and a solar panel,
- Clean delivery kits that include sterile gloves, alcohol gel, scalpel, umbilical cord clamp, and sterile gauze (in case women ended up delivering at home), and
- Work accessories such as hat, vest, raincoat, and hands-free flashlights.

Box 3 The Mama River Programme

The full scale of possible cross cutting benefits becomes apparent when gender relationships and dynamics are explored through the lens of innovation ecosystem.

Knowledge side

Participation:

The relevant actors are women and men in their roles as: (i) academic researchers advancing scientific understanding of maternal health and safe pregnancy, and paediatrics of newly born (boys and girls); (ii) telecommunications engineers developing new protocols for processing digital information; (iii) economists analysing impact of public health measures; (iv) human-computer interaction researches advancing understanding how people solve problems using computers; (v) social scientists developing understanding of community social structures, relationships and interactions.

Outcomes:

Understanding sex-gender difference effects influences: (i) scientific understanding of maternal health, ii) scientific understanding of social behaviours related to pregnancy, including those of men; iii) assumptions made in how knowledge is communicated using computers and mobile phones; (iv) assumption made when designing geo-positional software for mobile communication; (v) design of interfaces to support human communication mediated through mobile devices.

Cross cutting impacts:

The cross cutting benefits arise through the interdisciplinary nature of the Mama River Programme, which when fully considered can improve and expand: (i) collection and use of new evidence to inform further research on maternal health, and related social and health conditions found in the remote regions; (ii) data about wellbeing of women, men and children in remote communities, which can help inform public health policies and strategies; (iii) multi- and inter-disciplinary knowledge sharing.

Innovation/technology side

Participation:

The relevant actors are women and men in their roles as problem owners and co-solvers who influence how the innovation problem is perceived and solved, including: (i) the community agents delivering health information and services; (ii) the pregnant women themselves as users of the toolkit; (iii) the fathers, as well as other women and men living in the same communities; (iv) the communication and medical staff on the Medical Ship; (v) the government officers responsible for social services who will be responsible for the service in the long term.

Outcomes:

Interactions between innovation actors are directed to towards producing effective solutions to specific technical problems, the degree to which sex-gender difference effects have been included in the information will decide if: (i) the delivery kits and items needed for ante and post natal care are accepted by women; (ii) how women and men interact with mobile phones for communication and training; (iii) how well does the software for gathering data recognise details that are specific to women in different maternal situations; iv) are health training materials for community agents free of gender bias; (iv) are mobile communication network connecting remote communities and the medical personnel on the ship accessible to women and men.

Cross Cutting Impacts

The cross cutting benefits arise from the interactions between professionals and practitioners where expertise and experience is shared and common understanding develops through: (i) collaborative networks of different categories of health practitioners; (ii) network of different stakeholders in the development programmes; (ii) education and empowerment of remote communities; (iii) empowerment of the women; (iv) formal identification of babies as citizens; (v) improved welfare of remote communities.

Products/services market side

Participation:

The relevant actors are women and men decision makers in their roles as: (i) healthcare educators; (ii) government officials responsible for health services; (iii) employees of NGOs; (iv) policy makers, (v) community leaders; (vi) advocacy members promoting women's health; (vii) consumers; (viii) opinion makers.

Outcomes:

Important tangible results include: (i) quality health service; (ii) improved human capital of community agents; (iii) communication and support materials and products; (iv) training materials.

Cross Cutting Impacts:

Cross cutting benefits can arise because gender equality issues influence: (i) policy design; (ii) healthcare services provision; (iii) applications of demographic 'big data' in health; (iv) development of Internet of Things applications; (v) community self-reliance and resilience.

Gendered innovation and societal challenges

In traditional innovation systems the key actors are industry, universities and government. These systems focus on competition and commercialisation of specific technologies. However, different approaches to innovation are needed to tackle global societal challenges related to climate change, energy environment and demographics, but also social security, health and education. These problems transcend sectoral and disciplinary boundaries, and geographic borders. The strength of the gendered innovation approach lies in its capacity to provide a common thread in how problems are perceived, understood, and solved. It can also help identify fresh opportunities to create useful products and services based on the scientific evidence showing when, why and how sex-gender differences matter. In the sections that follow, we show how.

Climate Change

Climate change is an area of great societal concern where gender issues have been marginalised until now. It is generally agreed that the socioeconomic impacts of climate change will affect the poor more severely than other groups in the population, and will exacerbate already present gender inequalities . This means that we can expect women to suffer more than men. These issues are intertwined with, but cannot be resolved fully through policy agendas that target socioeconomic transition towards a low-carbon development. Policy makers must also pay attention to how sex-gender differences[72,73]influence human adaptation to climate change. For example:

- As temperatures increase, more water will be contaminated with pathogens and women more often come in contact with poor-quality water and are more vulnerable to water-related diseases than men (more women die of dirty water than of AIDS[74]).
- Women bear the main burden of caring for those who are ill, and this burden is likely to increase as a consequence of climate change effects.
- Due to their physiology, women are more vulnerable to extreme weather effects than men[75]
- Women's traditional roles (looking after children and elderly) and cultural restrictions may hamper their self-rescue efforts during natural disasters.[76]
- Women's mortality, especially of elderly and pregnant women, related to heat waves is higher than the mortality of men.
- Women may have less access to vital information on mitigation or adaptation strategies because of isolation and time constraints due to the caring and other domestic responsibilities.
- Climate changes that will result in increased temperature and different levels in humidity to those that can benefit or can be tolerated by the skin will disrupt the delicate balance between normal and pathogenic skin conditions and result in increased dermatological problems[77]for both women and men.
- Increased exposure to UV radiation will result in greater prevalence of skin cancers[78]and physiological differences in skin properties of women and men may differentially impact on their risk of skin cancer.

Education

Education and training for professional and personal development is accepted as being fundamental for economic growth, poverty reduction, and to social change. However, widespread gender disparities exist, especially in low-income countries, with regard to the access, completion, and level of education. Education of girls (as compared to boys) is widely recognised as producing additional socio-economic gains that can benefit entire societies through increased economic productivity, higher family incomes, delayed marriages, reduced fertility rates, and improved health and survival rates for infants and children[79].

Gendered innovation applied to education has the potential of achieving a wide range of cross cutting benefits through new products and services based on scientific understanding of sex and gender, and knowledge of how social conditions and relationships contribute to gender inequalities. The new educational products that are needed include:

- Sexual health education programmes that can be incorporated within school curricula.
- Teacher training programmes with integrated gender-related content.
- Guidelines and self-assessment measures to test teachers' gender attitudes and identify gender biases.
- Professional and leadership training materials designed to increase the number of women in education decision roles (e.g. as school administrators).
- Materials to promote gender knowledge in adult literacy and numeracy programmes.
- Practical support measures (e.g. utilising digital technologies[80]) enabling girls to complete primary and secondary education.
- Data collection, indicators and statistical analyses of participation in, completion of, and transition to higher levels of education.

Food and nutrition

Food security and nutrition are essential to poverty alleviation programmes and are well suited for adopting gendered innovation approach that maximise opportunity for achieving cross cutting benefits. This can be demonstrated through the example of marine and coastal services ecosystems[81]. These ecosystems can be the source of diverse income growth opportunities for women and men, including: fishing of wild fish and aquacultures; coastal agriculture (e.g. seaweed); mining of sea minerals (e.g. salt); land reclamation; coastal development/urbanization; tourism and recreation; harbour facilities and shipping; and defence.

In many low-income countries, women represent the majority of wild fish marketers and also the majority of wild and farmed fish consumers. Inclusive innovations that improve gender equity in aquaculture value chains could involve technologies for processing fish to developing value-added products. In addition, applying scientific understanding of how sex differences control reproduction, maturation and growth of fish can result in wide range of innovation impacts. It can contribute to innovations that improve management of aquacultures for sustainable production of nutritious food by identifying, for instance, fish species in which the male grows bigger (e.g. tilapia, popular in Africa) and those where the female grows bigger faster (e.g. turbot, widely eaten in Europe)[82].

Similar considerations can be applied for improving production of food crops that rely on animal

pollination because research shows that availability of pollinators improves yields and quality of crops, thus requiring less land and fertilizer to produce the same results[83]. Understanding how bees are attracted to male and female flowers, and when a plant's fertility is highest, could also help enhance pollination success. The cross cutting benefit is promotion of smart bee keeping to improve the livelihoods of smallholder farmers, many of whom are women. Understanding the differences in how male and female flowers protect themselves from pathogens can help develop better more natural controls for growing edible plants, but also help women farmers who have more limited access to agricultural resources than men learn how they can protect plants with less chemicals.

Safe water

Water has economic, social, environmental, as well security dimensions. Global resources of fresh water are limited. Population growth, climate change and consumption habits diminish them even further. Water is a crucial element in the UN 2030 Agenda for Sustainable Development[84]. Gendered innovation that targets technologies enabling access to safe water for all has the scope of producing a wide range of cross cutting benefits[85], because access to safe water is important for:

- Tourism
- Natural disaster management (e.g. coping mechanisms for communities after flooding)
- Peace oriented military service (soldiers protecting civilian in risk areas)
- Recreational services (swimming pools, lakes)
- Agriculture services (e.g. irrigation of vegetables & fruit)
- Private water supply/waste (wells, septic tanks)
- Food production (cleaning fish, vegetables)
- Internet of Things (e.g. using environmental sensors and mobile phones for monitoring contamination)
- Big Data(monitoring reporting of occurrences of flooding)
- Water recycling technologies (making waste water safe)
- Water networks (better pipeline efficiency)
- Sanitation measures
- Water pumps and storage
- Education (water that may look clean but may not be safe)
- Usage pricing

Transport

Understanding the causes and consequences of serious and fatal road traffic injuries has been historically dominated by studies that focus on men (and the transport conditions in the developed world), owing to their high rates of exposure and tendency to adopt riskier behaviours.

This has led to innovations focused on injury countermeasures (e.g. occupant protection in cars) designed to fit the male anthropometry and biological characteristics and ignoring design parameters that are relevant for female road users (e.g. shorter stature and difference in musculature)[86].
With differences in exposure to driving risk between men and women applicable globally, it is important for innovation to create safety measures that have equitable performance and health outcome for either sex. In most developing countries, which have a disproportionate share of global road injuries, risk prevention factors such as helmet and belt use may vary dramatically between the driver and the passenger[87]. In these countries where women account for a large proportion of vehicle passengers and pillion riders, it is important that transport policies and interventions are targeted at women as well as men.

ICTs

In general, the way ICT is applied today has largely been an extension of our socialization and part of the existing basic services, from which women have been historically excluded as innovators. The priority for applications of ICTs has been to promote efficiency, productivity and cost-effectiveness, where, historically, men have been the dominant group. Therefore, the way ICT is applied today has little to do with the appreciation of the needs of women. The richness in diversity of needs, perspective, behaviours and preferences that characterise women and men has been overlooked as source of ideas for new products and services.

The perception of women being passive consumers of ICT rather than producers extends to the work-related use of ICTs. Even in job areas where women are in a majority such as health care and social services, for example, development of ICTs to support such work has been conducted in a largely gender-blind way[88]. A gendered innovation approach would benefit development of ICT applications for healthcare relayed problems. For example, opportunities for innovation that address different needs of women and men include:

- Assistive technologies
- Elderly healthcare
- Social care
- Social networks
- Advisory services
- Medical devices.

In principle, any application of ICT requiring, or dependent on, human input or interaction may benefit from asking the following gendered innovations questions:

- How can ICTs play a role in providing quality services to women and men living in urban, rural and remote regions?
- Which applications provide best potential with respect to effectiveness, adaptability and sustainability and answering the different needs of women and men?
- What are the cultural and gender challenges to setting up ICT programmes in developing countries?
- How do women and men access and use different ICT services?

Principles for mainstreaming gender into research, innovation, and development measures

This report has identified several major policy initiatives that seek to achieve socioeconomic growth and societal wellbeing through science and technology. Integrating gender perspective into design and implementation of the related strategies, programmes and projects should be done in a principled way, based on extensive scientific evidence. There are already many guidelines available to promote a systematic approach. The Seoul Declaration described below condenses that knowledge into 10 principles.

The Seoul Declaration

1. **COLLABORATE** by creating national and regional ecosystem promoting alliances to enable continued dialogue on common gender issues in inclusive innovation, which are of concern to policy makers and stakeholders in science, innovation, industry & society.
2. **ASK** to ensure quality of innovation process and outcomes, whether, and in what sense, biological sex and gender differences are relevant in the objectives and methodology of the innovation project.
3. **ESTABLISH** innovation protocols, policy frameworks, innovation standards & regulatory regimes to ensure safety and efficacy of technological outcomes for both women and men.
4. **AGREE** on accepted terminology, schema and models for representing and reporting the role and effects of biological sex and gender in inclusive innovation and inclusive growth contexts.
5. **CREATE** fresh opportunities for developing new markets for new and improved technologies by advancing gendered innovation ecosystems. Such systems can be constructed by exploiting connections between: 1) gender sensitive research; 2) the different interests and product needs of women and men; and 3) making better use of the available female scientific and creative capital.
6. **INVOLVE** more women in innovation value chains - in idea creation, development, and implementation. Evidence shows that: 1) gender balance in a team improves its collective intelligence; and in 'crowd sourcing' innovation, women outside the formal innovation circles contribute better solutions than other problem solvers.
7. **IDENTIFY** statistics, indicators, and methods for collecting sex-disaggregated data to enable better understanding of the current situation regarding gender equality in innovation at institutional, national, and regional level.
8. **EDUCATE**, starting with schools and including university students, researchers, mangers of research and science communicators about the importance of including gender perspectives in research and innovation.
9. **JUDGE** the potential of women and men as active actors in innovation process using clear and fair assessment criteria, monitoring outcomes for signs of gender bias in order to improve the success of innovation process.
10. **CREATE** conditions for using gendered inclusive innovation to achieve cross cutting benefits through practices that build on shared policies and programmes for inclusive socioeconomic growth.

Mainstreaming gender into UN Sustainable Development Goals

The scientific evidence already available shows that gender inequality issues 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. It also shows that better understanding of sexual reproduction of plants, wildlife and farmed animals can identify important conditions for protecting biodiversity, ensuring wellbeing of terrestrial and marine ecosystems and habitats, and advancing sustainable agricultural methods. Such knowledge can enhance the success of the implementation measures.

The 17 SDGs promise to be more gender-aware than the Millennium Development Goals, however, although one goal, SDG 5, and its nine targets are dedicated to achieving greater gender equality and empowerment of women, among all the targets, less than 10% recognise the special needs of women and girls. This is in sharp contrasts to the scientific examination of the SDGs conducted by the International Council for Science, which identified 78 scientific topics involving "gender" and/or "women" as the main and a separate concern[89].

The scientific evidence already available shows that gender inequality issues 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. It also shows that better understanding of sexual reproduction of plants, wildlife and farmed animals can identify important conditions for protecting biodiversity, ensuring wellbeing of terrestrial and marine ecosystems and habitats, and advancing sustainable agricultural methods. Such knowledge can enhance the success of the implementation measures[90]. The following three examples explain this purpose:

In **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. For instance, in some fish species the male grows bigger (e.g. tilapia, popular in Africa) and in others the female (e.g. turbot, widely eaten in Europe). Furthermore, such measures could also provide opportunity to enhance the role of women in aquacultures. 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. Understanding how bees are attracted to male and female flowers, and when a plant's fertility is highest, could also help enhance pollination success, and promote smart bee keeping to improve the livelihoods of smallholder farmers, many of whom are women.

In **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 development5, and the socio- economic implications for these mothers, their families and society.

In **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.

Mainstreaming gender into Africa 2063 agenda

Innovation in Africa is a hot topic of the moment and a key aspect of future success on the continent especially as envisaged by the African Union's Agenda 2063: The Future We Want for Africa[93], where innovation is one of the crucial factors in its achievement. In order for this to happen, serious efforts need to be made to continue finding new and inventive ways to make life easier by improving living standards on the continent. A big part of innovation for socioeconomic improvement will be achieved if the strategy for education[92] can be realised in tandem with Agenda 2063. The contributions of gender sensitive inclusive innovation could be significant[93] and could cover:

- Measures promoting women in teaching profession
- Ensuring quality (bias free) and relevance (gender) teaching at all levels of education
- Developing conducive learning environments ensuring access to quality education for girls and boys
- Harnessing the capacity of ICT to improve access, quality and management of education and training systems
- Measures promoting knowledge and skills needed for jobs
- Measures for harmonization of education systems
- Literacy programmes across the continent to that include women
- Gender aware science curricula targeting youth training and dissemination of scientific knowledge into cultures and society
- Vocational opportunities for women at both secondary and tertiary levels that link work and training systems[94]
- Peace education and conflict prevention and resolution with attention to gender roles and effects

Examples of how policy makers have integrated gender mainstreaming into national research and innovation strategies

Vinnova

The Swedish Governmental Agency for Innovation Systems (VINNOVA) aims to increase the competitiveness of Swedish researchers and companies. VINNOVA'S task is to promote sustainable growth in Sweden by funding needs-driven research and the development of effective innovation systems. VINNOVA'S annual investment budget for new and on-going projects is EUR 220 million. An important part of VINNOVA'S activity is increasing the cooperation between companies, universities, research institutes and other organisations in the Swedish innovation system. VINNOVA strongly promotes gender equality in these context as an enabler of effectiveness of innovation by recognising that society is gendered and women and men bring with them different perspectives on problems but also that they are expected to be different not so much in their capacity to be innovative but in attitudes to risk, for example. Men are expected to take more risk when innovating and sharing ideas than do women. Failure is less damaging to men because that's what is expected of them. Women are expected to be less risky and this appears to constrain both their degree of innovation and willingness to innovate.

German Federal Environmental Agency

During 2014-2015 the German Federal Environmental Agency (UBA) undertook an extensive gender mainstreaming effort at both organisational and research levels. At organisational level this included:

- Integration of gender actions into strategies and goals
- Creating steering team consisting of Central Steering Department, Presidential Department, Gender Equality Commissioner and Gender Mainstreaming Research Officer
- Monitoring and reporting in gender equality plan
- Advanced education about gender competency for managers
- Advanced education about gender mainstreaming instruments for practitioners/ researchers
- Gender balance in relevant commissions
- Procurement of advanced education (quality criteria)
- Gender mainstreaming in Occupational Health Management
- Gender-disaggregated evaluation of Re-integration Management (BEM) and Social Counselling Service
- Gender mainstreaming integrated in UBA's Joint Rules of Procedure
- Gender balance in relevant commissions (legal basis)
- Gender mainstreaming integrated in UBA's Mission Statement

The UBA's gender mainstreaming actions also covered the funded research where biological and sociocultural differences can determine outcomes. For example, biological dimensions of environmental health that differ for women and men include: body weight, fat-muscle

composition, toxic effects of chemicals and pollutants, metabolism rates and pathways. In the case of chronic exposure to copper, which can damage liver and kidneys – women show greater levels of copper in blood then men, and this has been linked to oral contraceptives use . Socially driven environmental health gender dimensions include behavioural differences such as: smoking status and impact, nutritional status and behaviour, consumer habits, time spent on household chores. For example, women experience more frequent allergies to fragrances used in washing and cleaning agents – linked to the women's greater time spent on doing laundry, cleaning and washing dishes[96].

The European Union's Horizon 2020 Programme

The EU Horizon 2020 programme for research and innovation places explicit requirements in how gender should be considered in projects. Applicants to Horizon 2020 are encouraged "to promote equal opportunities in the implementation of the action and to ensure a balanced participation of women and men at all levels in research and innovation teams and in management structures". They are also encouraged to address gender dimension in research content. The gender dimension is explicitly integrated into a range of topics across all the sections of the Work Programme. A topic is considered gender relevant when it and/or its findings affect individuals or groups of persons. In these cases, gender issues should be integrated at various stages of the action and when relevant, specific studies can be included. These topics are flagged to ease access for applicants. This should not however prevent applicants to a non-flagged topic from including a gender dimension in their proposal if they find it relevant. Evaluators are required to check how sex and or gender analysis has been incorporated into the proposals submitted under the flagged topics. A novelty of Horizon 2020 is the inclusion of gender training among the eligible costs of an action. The aim is to help researchers to further develop and share gender expertise in relation to the funded project.

Conclusions and Recommendations

The main objective of this report was to examine how gender fits into the OECD vision of using inclusive innovation to improve the lives of all, and in particular the lives of the poor and vulnerable groups in society, and its link to the OECD vision of "Creating Our Common Future through Science and Technology" . The gendered innovation approach is directly relevant to both because women make up the largest proportion of the poor and vulnerable in the world. Essentially, "inclusiveness" and "our common future" cannot be achieved if they fail to recognise and respond to women's needs when these are different to those of men.

This report provides numerous examples of scientific evidence, and refers to specific innovation programmes, to show why gendered innovation can help achieve the vision of inclusive innovation and our common future.

The scientific evidence of sex-gender difference effects provide important knowledge to enrich the OECD criteria of inclusive innovation, namely :

- Affordable access to goods and services
- Sustainability based on market mechanisms and not continued government support
- Quality of goods and services, and livelihood opportunities
- Access to excluded populations (poor, disables, migrants, women, elderly, ethnic minority groups)
- Significant outreach – benefits for significant proportion of the population.

The report shows that if the essence of innovation is to produce "improvements over current practice achieved through the exploitation of advances in knowledge, resulting in new goods and services and new ways of supplying existing goods and services", then we must ask who will drive this and who will benefit from it:

- Will the resulting goods and services work equally well for women and for men?
- Is current practice subject to explicit or implicit gender bias that promotes socioeconomic and welfare inequalities between women and men
- Are the goals of the proposed innovation based on science knowledge that itself contains gender bias, e.g. studies that used the 'male' as the norm, or have not disaggregated data by sex?
- Has the analysis of market opportunities taken into account the preferences, values, and behaviours of both women and men?
- Were both women and men equally involved in the innovation decision processes?
- Are there possible cross cutting impacts associated with the problem/solution that are different for women and men?

The report shows that the gender-neutral approach used in most innovation policies, strategies and programmes, historically and today, is essentially flawed because it promotes male gender bias in the design and implementation of innovation strategies and programmes. The gendered innovation approach prevents bias influence outcomes by introducing analysis that can identify improvements along three gender dimensions:

- Participation, i.e involving both women and men in innovation process as decision makers and beneficiaries because research shows that this can enhance creativity, efficiency, and the take up of new technologies

- Outcomes, i.e ensuring that the scientific advances used as the source for innovation ideas are not gender biased, e.g. based on evidence for males only whilst the planned innovation is intended for both women and men
- Cross cutting benefits, i.e innovations that can lead to interconnected socioeconomic impacts at several levels.

Failure to recognize the role of sex-gender difference effects in the design and implementation of innovation strategies can lead to:

- Overlooking potential impact of sex-gender differences on the quality of innovation outcomes for women and men
- Underutilization of available female creative talent
- Failure to recognize potential knowledge applications and market opportunities
- Reinforcement of negative attitudes to innovation in society and resistance to technological advancement.

The report shows how gender knowledge can help inform the implementation of the priority goals behind the OECD policy of Creating Our Common Future Through Science and Technology , namely:

- Improve the design and implementation of innovation strategies
- Improve impact of public investment in science and innovation
- Promote social responsibility of science policies in 21st century
- Promote science and innovation for health
- Create new technologies for a sustainable future and the green economy
- Promote science and innovation for global inclusiveness.

Policy makers worldwide can learn from actions taken in Europe, and in particular by the European Commissionin, focused on:

- Mainstreaming gender equality in the design, development, implementation and evaluation of science and technology public policies and budgets
- Strengthening accountability and mechanisms for gender equality and mainstreaming initiatives across and within government bodies making up national science systems
- Achieving gender balanced representation in decision-making positions in science systems by encouraging greater participation of women in research and innovation at all levels, as well as in higher education, government, and professional bodies.
- Taking adequate measures to improve gender equality in science and innovation knowledge making and application practice
- Strengthening international and sectorial co-operation through knowledge sharing, lessons learned, and adaptation of good practices on gender equality and mainstreaming initiatives within national science and technology systems.

It is hoped that the evidence presented in this report will be used by the OECD to close gaps in their efforts to promote gender equality, which until now targeted women's participation and leadership in governments, parliaments and judiciaries but not in science and innovation. And, the same is hoped for United Nations' Sustainable Development Goals agenda, and the African Union's Africa 2063 plan.

The main conclusion of this report is that if scientific and technological advances are to be successfully used as drivers of socioeconomic growth **for all**, gender inequality concerns specific to research, innovation and development contexts must be recognised when designing and implementing innovation policies, strategies, and programmes to achieve the societal and economic improvements needed.

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Producing Organisations

The Gender Summits were established in 2011 under the overarching theme of "Quality Research and Innovation through Equality" as part of the genSET project, coordinated by Portia Ltd. They are creating regional and global multi-stakeholder communities committed to enhancing scientific excellence by: removing gender bias from science knowledge making; advancing gender equality in science structures and practices; and applying understanding of gender issues to advance more sustainable and effective research and innovation. Their objectives are to: 1) Develop national, regional and global communities as agents of change; 2) Develop evidence-based consensus on the actions needed and the ways of implementing them in specific national or regional contexts; 3) Demonstrate positive effects of gender balance and gender diversity in research and innovation process; 4) Demonstrate how integrating gender dimension in research and innovation content improves quality of results and outcomes, and to 5) promote gender aware solutions to societal problems, e.g. urban quality; human adaptation to climate change; food security, and transport and mobility.

In 2011, **The Korea Center for Women in Science, Engineering and Technology (WISET)** was commissioned by the Korean Ministry of Science, Education and Technology and the Korea Advanced Institute of Women in SET (Science Engineering and Technology) to create conditions under which women can play a central role in science and technology sectors. WISET aims to establish a total support system for Women Scientists and Engineers by creating a sustainable eco-system through domestic and foreign integration, cooperation, exchange, and solidarity; by reinforcing the status as a total support center toward fostering and utilizing women scientists and engineers; and by building a global network hub for women scientists and engineers. WISET carries out five core projects: 1) Supporting an innovation system in science and engineering and policy study on women scientists and engineers; 2) Developing support measures through analysis on legislative operational output, policy outcomes, and related domestic and international policy studies; 3) Nurturing a self-sustainable ecosystem by introducing and systemizing a lifecycle tailored mentoring system; 4) Establishing an interdisciplinary cross-matched network among different generations to foster women in SET, and 5) Fostering and systemizing the utilization of a core workforce of women scientists and engineers.

Portia Ltd designs and implements effective, evidence-based strategies for advancing quality of research and innovation through gender knowledge. Our work covers gender equality issues in STEM and the gender dimension in the content, process and impact of science (STEM) endeavours. We work through national and international partnerships, involving the scientific community, industry, policy makers and gender research scholars, to enhance science knowledge making; improve institutional practices and process; promote human capital; and ensure compliance with regulation. We believe firmly in putting the views and needs of women at the centre of the gender equality debate in science, and as a key to achieving sustainable economic growth and promoting Europe's role as a global R&D leader. Portia co-founded the Gender Summits in 2011 as part of an EU project we co-ordinated, genSET.

Gender in science and innovation as component of **inclusive** socioeconomic **growth**

"We need to ask the question:
will the **solutions** work
equally well
for women,
will they work
equally well
for men:
otherwise,
we are wasting our time"
(Peter Piot
co-discover of the Ebola virus)

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