Gender Equality in Science, Technology, Engineering, Agricultural Sciences and Mathematics (STEAM) Academic Pipeline

Challenges Transferring Knowledge to Practice

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Executive Summary

This report is the outcome of an eight-week study on the bibliography on the status of women in Science, Technology, Engineering, Agricultural Sciences and Mathematics (STEAM), employed in research and higher education institutions worldwide. Attention has been given to steps that "feed" the academic pipeline as a continuous life cycle process, such primary, secondary and tertiary education and overall employment of women in the world.

It seemed important to inventory the factors known to contribute to the evasion of women from academic life, and to revise interventions that have documented efficacy (or at least have the potential to do so), based on broad program scope and high throughput outreach. We came across a number of challenges that hinder our capacity to provide a clear picture on the academic pipeline in the developing world, with the exception of Agricultural Sciences in Africa.

This literature review highlights major obstacles to achieving knowledge transfer to practice, when it comes to gender equality in STEAM academe in the developing world: lack or scarcity of data, or insufficiently robust data, compliant to international standards, and statistically relevant, that can be used to provide guidance for program evaluation and dissemination, as well as policy formulation. Unless these data are collected, properly analyzed and disseminated, gender responsive policies, plans and actions are at stake. The current inadequate data related to the underrepresentation of women faculty in STEAM careers undermines our capacity to provide adequate, scalable, replicable and sustainable solutions for gender inequalities. United Nations has called for an urgent "data revolution". It is time for a concerted effort.

The Labor and Education Life Cycle

Despite considerable progress in promoting gender equality and narrowing the gender gap in education and labor, women are still underrepresented, underpaid, receive less recognition, have lower access to resources, are disproportionately affected by economic, social and environmental stresses, and experience unequal rights, unequal power relations, discrimination and violence in both developed and developing countries.

In education, gender equality efforts have been fruitful. Gender parity has been reached in two-thirds of countries at either primary, secondary or both levels. Gender parity at tertiary educational level has been achieved in 149 countries. Women now represent the majority of tertiary students in 93 countries, in contrast with 46 countries where men are majority. In postgraduate education, women have slightly surpassed men in 3 of the 5 world regions in Master's degree attainment (~58%), but are disproportionately lower in Ph.D. attainment in 4 regions (~29%). Large differences remain among degree attainment in "male-dominated fields". Women represent 33% of "researchers" in higher education in Europe (EU-28), 46% in the U.S., and varying rates in developing countries: Argentina (53%), Indonesia (31%) and Kenya (26%), for example. Data are missing in many developing countries.

The Leaky Academic Pipeline

Along their career progression, women's representation decline in the academic pipeline at varying rates worldwide, as a result of many factors, including but not limited to unequal access to resources, career development opportunities, biased performance evaluation and promotion policies. Many interventions impacting women's hiring, retention, promotion and advancement to leadership positions have been implemented worldwide, some based on U.S. and European research findings. However, qualitative and quantitative data are lacking to characterize the academic pipeline in the developing world, as well as determine efficacy of these interventions. Populations are highly heterogeneous, and regional socio-economic, cultural and political issues contribute to create unique challenges to gender equality. Studies to examine gender, racial, ethnic and field-specific contributors must be carefully designed and assessed to avoid averaged findings. Evidence-based, country-specific solutions are needed.

Achieving Cultural Change

One overarching strategy, found essential across gender equality interventions worldwide is cultural change. Changing culture is feasible but requires institutional changes, with enforceable policies and accountability measures. The engagement of formal and informal community groups ("communities of practice"), who share vision and responsibilities, can have an extraordinary impact in rule-setting and rule-enforcement. Sustainable, long-term efforts are needed to disrupt the ingrained academic "male-dominated" culture, transforming it to women friendly. Positive culture can buffer career challenges and vulnerable transitions. Negative culture produces dissatisfaction, and increase the "leak". Many interventions have shown to promote cultural change in all levels of education and employment worldwide, including but not limited to STEAM academia. Data to monitor career progression in STEAM is needed in the developing world. Data-driven actions and policies are need to increase rates of women faculty's hiring, retention, promotion and advancement to leadership.

Data Revolution

Developing evidence-based interventions and policies is a difficult process in developing nations. Data reporting is not a common practice. When data is available, quite often it does not conform to international standards. Data quality and integrity are essential to build national robust statistical capacity. Harnessing the benefits of statistical integration requires investments in the collection of internationally comparable sex-disaggregated statistics and the use of a variety of indicators to capture the complex economic, societal and cultural environments across regions and countries.

Efforts need to be intensified to encourage and accelerate the use of international, standardized statistical indicators to allow cross-country comparisons and progress over time. The U.N. Secretary General's Independent Expert Advisory Group on the "Data Revolution for Sustainable Development" acknowledges the seriousness of this scenario and is developing joint efforts to overcome differences in capabilities and resources devoted to basic data collection, compilation and analysis. For competing sources of data, data curation needs to be undertaken to produce the most reliable data set that complies with international standards.

Transferring Knowledge to Practice

Gender equalities will not be mitigated by global solutions, given the complexity and extent of determinant factors. A diversity of approaches need to be undertaken. Cultural change is critical in all interventions across developed and developing world, especially where women and girls' education is not prioritized, and in "male dominated" fields of study. Knowledge-based initiatives, involvement of global and local allies, in-depth gender impact metrics matched with funds will enable sustainable changes in women's empowerment and representation in society at large and in STEAM education and employment.

Closing Remarks

In closing, there is a global consensus on the importance of public action on gender equality. Reliable, well-structured data is needed to understand the career progression of women in STEAM academic pipeline. Research findings and data on the academic "leaky pipeline" from U.S. and European institutions can be a valuable framework of reference; however insights and understanding of complex socio-economic and cultural determinants that are driving women out of the STEAM academe and workforce in the developing world are highly needed.

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Women as Integral Part of World's Labor Force

Despite considerable progress made in promoting gender equality and narrowing gender gap in the world's workforce during the past 50 years, much of women's work remains in sex-stereotyped occupations that are more precarious, vulnerable and poorly paid than men's. As a consequence, women are disproportionately affected by global financial and economic crisis and hence poverty than men.

The 2010 United Nation's Millennium Development Goals (MDG) Summit [(1)] recognized the intrinsic value and urgent need for gender equality. The summit called for an action plan to ensure gender parity in education and health, and economic opportunities would be achieved in 2015. We are yet to see gender equality achieved in developing economies, as well as in many sectors of developed nations.

Analysis of the *International Labor Organization's 2012 Global Employment Trends for Women*[(2)] indicates that the gender gap in employment-to-population rate remained high at 24.5 points. Just in the 2002-2007 period, women lost 13 million jobs. Moreover, women are limited in their choice of employment across sectors: they are moving out of agricultural jobs in developing economies and out of industry and into services in developing economies. Women represent 40% of the world's workforce, but have just 1% of its wealth, according to *2012 World Bank Report*[(3).] ***Table 1*** highlights some of the current findings on women's role in the global labor force.

Research findings from the world's most influential institutions (World Bank, International Monetary Fund, World Economic Forum, Goldman Sachs, McKinsey & Company, Ernst & Young, the, and others) clearly demonstrates that women's full economic participation leads to greater economic development and competitiveness. More than ever, gender equality is an important business practice: In the developing world, women who earn an income unleash a multiplier effect, as they are more likely than men to put money right back into their families and communities, driving both economic growth and social progress. Gender equality has a recognizable downstream effect on generations to come, as mother become role models to their daughters and their sons become women champions.

Table 1 - KEY FINDINGS – Women in the World's Labor Force

- Women represent 40% of the world's workforce, 43% of the world's agricultural labor force and more than half of the world's university students (World Bank, 2012).
- Over half a billion women have joined the world's labor force over the last 30 years as women's participation in paid work has risen in most of the developing world (World Bank, 2012).
- Gender gaps in employment have worsened in many regions. Women have higher unemployment rates in Africa, South-East and South Asia, and Latin America (ILO, 2012).
- Negative gender gaps have occurred in East Asia, Central and Eastern Europe, and more recently in advanced economies (ILO, 2012).
- In 2012, at a global level, a third of women were employed in agriculture, nearly half in services and a sixth in industry. Women's industrial share only slightly rose over the past 20 years as most women are moving out of agriculture and into services (ILO, 2012).
- Gender gaps remain particularly large in groups where ethnicity, geographic distance and other factors (such as disability or sexual orientation) compound gender inequality (World Bank, 2012).

Gender equality can have a large impact on productivity and economic development[(4-7)]. Women's labor is underutilized or misused. Women face cultural, educational and socio-economic barriers, do not enter certain occupations, do not have earnings comparable to men or have the same access to public and private resources and services. Women are often exploited and provide unpaid care work. Women farmers, for example, often lack secure land tenure. To achieve food security and sustainable livelihoods, women need access to and control over agricultural assets and natural resources[(8)].

Analysis of gender equality is hampered by many factors. For example, the welfare of men and women living in the same household is difficult to measure separately, since it is typically measured at a household level. Income and social class are often intertwined with gender. The more educated the parents, the less gender stereotypes apply to their daughters.

The systematic exclusion of women in the world's workforce, their restricted access to education, health, resources and public services is imposing a tremendous cost on productivity, sustainable development and economic progress worldwide. It diminishes an economy's capacity to grow and raise living standards [4-7].

Gender disparities remain high in a variety of sectors, even in advanced economies. The most persistent and pervasive global gaps are listed in ***Table 2***.

Table 2 – Persistent Gaps in Gender Equality (World Bank, 2012)

- Higher mortality rates among women and girls (middle- and low-income countries).
- Disparities in girl's schooling, with lower primary and secondary school enrollments for girls in many countries.
- Unequal access to economic opportunities: (women are more likely to have unpaid work, earn less, have lower credit).
- Lower power in households and in society (lower decision making involvement, participation in politics, in leadership positions).

Programs and policies to reduce gender gap have the potential to significantly improve economic growth and standards of living for women and girls in developing economies, with impact on poverty reduction, health and wellbeing. We are at a critical juncture in the path of closing the gender gap. Capacity development and investment in the following frontlines is critical to achieving gender parity in the developing world:

(a) Robust data collection methods, using validated international indicators of gender, race and ethnicity, socio-economic status, as well as commonly agreed methods of data curation, statistical analysis, and submission to a centralized database, where quality and integrity of submitted data is evaluated prior to distribution;

(b) Data-driven, region- and country-specific gender equality interventions must be tested, validated and disseminated;

(c) Data collection on postgraduate education, including percentage of women employed as postdoctoral researchers or its equivalent, Master's and Ph.D. degree holders, using "as standardized as possible" fields and sub-fields.

(d) Data collection on employment rates of men and women in research-oriented colleges and universities, with harmonized fields of employment terms and ranks to enable cross-sector and transnational comparisons. This is critical to characterize the academic pipeline in developing countries.

(e) Research on the complex nature of factors that drive women out of academia, especially in Science, Technology, Engineering, Agricultural Sciences and Mathematics, with identification of the most vulnerable points in career development, to enable appropriate interventions.

(f) Holistic interventions, funding and resource allocation need to be considered, given the interconnectedness of the life cycle undergraduate, graduate and postgraduate education and employment; this is critical for development of STEAM capacity building with lasting economic impact in developing countries.

USAID Commitment to Gender Equality and Women's Empowerment

USAID has had a longstanding commitment to promoting gender equality and advancing women's empowerment. In the Department of State-USAID joint strategic goal framework, promoting gender equality and advancing women's empowerment are cornerstones of strategic goals and objectives (***Table 3***).

In recent years, USAID has carried on several measures and created initiatives to further its involvement in mitigating gender inequalities: Automated Directives Systems have been revised and updated; resources and personnel have been allocated to include women in high-level decision making, and to advance women in business, academia and business sectors.

Table 3 – U.S. Department of State-USAID Joint Strategic Goal Framework concerning Gender Equality and Women Empowerment

Strategic objective 1.2	*"Promote inclusive economic growth, reduce extreme poverty and improve food security".*
Strategic Objective 4.2	*"Promote and protect human rights through constructive bilateral and multilateral engagement and targeted assistance".*
Performance goal 1.1.2	*"Science, technology and innovation cooperation".*
Performance goal 1.2.2	*"Strengthen gender integration in development programming".*

Gender Equality in Education: Primary and Secondary Education

Girls and women are yet to experience full and equal opportunities for education and employment around the world. Even though there has been progress towards gender equality in developing countries at the primary level, the secondary and tertiary educational levels remain problematic[9].

Table 4 - Primary and Secondary Education

Areas of Progress	Areas of Continued Challenges
- 73% of 184 countries have achieved gender parity in primary and/or secondary education (or both). - Gross enrollment ratios are rising worldwide at secondary level. - Parity has been reached in more than one third of countries. - Largest gains in enrollment in secondary level occurred in Latin America and the Caribbean. - Females made impressive progress in the Arab States, East Asia and the Pacific, and South and West Asia.	- Sub-Saharan Africa has the lowest proportion of countries where parity has been achieved (2 out of 35). - Exclusion rates for girls are higher at secondary level than those in primary level. - Barriers in Secondary Education: Emotional and physical, including risk of sexual harassment and assault, traditional gender roles, and infrastructure problems. - Out-of-school adolescents are still a problem. - Inadequate or incomplete data reporting - Lack of statistical data analysis.

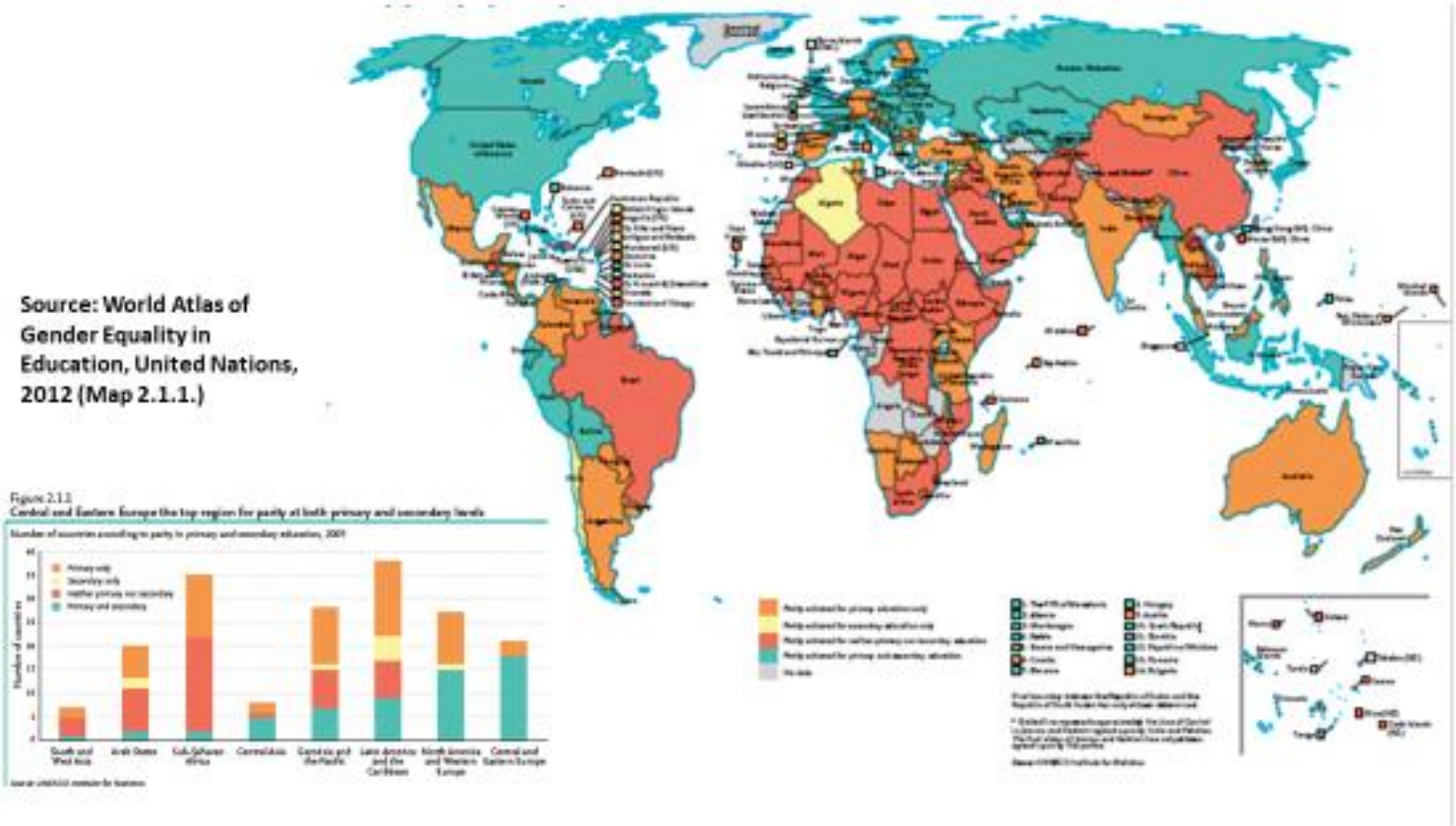
Enrollment in primary and secondary education have been rising since 1970 for both sexes, with greater progress in girl's enrollment. ***Figure 1*** shows gender parity (GPI between 0.97 and 1.03) in 184 countries. More than two-thirds of countries (73%) have reached gender parity at either primary or secondary levels, or both. Sub-Saharan Africa has the lowest proportion of countries reaching parity (2 out of 35).

Regarding secondary education, the proportion at which girls are excluded from education is higher at this level. There are many factors that may contribute to this: Emotional barriers and physical dangers, including sexual harassment and assault, social demands to conform to traditional gender roles, and school infrastructure (lack of bathrooms), to name a few[9]. ***Table 4*** lists the areas of progress and continued challenges in primary and secondary education.

Data simulation for a selection of 100 countries shows that increasing secondary education of girls by only 1% results in an annual income increase of 0.3% per capita. Such increase is substantial for many developing countries[10].

Gross enrollment ratios rising worldwide provide a larger pool of qualified students to transition to tertiary levels. Educational systems need to be looked at using a holistic approach, when issues of academic pipeline in STEAM are concerned. Reliable, high quality cross-country and cross-regional data is necessary to identify vulnerable transitions and design interventions.

Figure 1 - Gender Parity Index for Primary and Secondary Education



Source: World Atlas of Gender Equality in Education, United Nations, 2012 (Map 2.1.1.)

Technical Vocational Education and Training (TVET)

Technical vocational education in developing countries has many advantages: It is time- and cost-effective; it promotes a transition of adolescent girls from school to productive employment; it can target skills in high demand; and it can promote early economic independence. Training providers can conduct market assessments to implement training, and can make job placement an extension of training.

The Adolescent Girls Initiative[11], a public-private partnership is a successful example of technical education. It is under way in Afghanistan, Jordan, Lao People's Democratic Republic, Liberia, Nepal and South Sudan, and targets about 20,000 adolescent girls and young women ages 16-24.

Table 5 -Technical Vocational Education and Training (TVET)

Areas of Progress	Areas of Continued Challenges
- TVET is high on the agenda of governments. - Relevance concerns quality of training, employability, and involvement of the private sector. - Some countries have started designing training programs in priority economic sectors. - Countries that have increased the number of teaching staff: Ghana, Ethiopia and Mozambique.	- Countries have been slow to formalize internal or institutional-based quality audit strategies. - Development of credible and enforceable accreditation systems are undermined by lack of standards and norms. - Gap between policy formulation and implementation in Africa is common. - TVET is not growing fast enough. - Female enrollments in TVET are generally low. - More data is needed.

Table 5 briefly describes the current status of technical vocational education and training in Africa[9]. Areas of progress and continued challenges are likely to be shared among TVETs in other parts of the world.

Gender Equality in Education: Tertiary Education

Total enrollment at the tertiary level soared from 32 million (1970) to 165 million (2009) worldwide (500% increase). **Figure 2** shows tertiary enrollment for 185 countries. The most dramatic gains have been recorded in regions that had the lowest levels of enrollment in 1970: 24 times higher rates in Sub-Saharan Africa, 17 times in Arab States and 15 times in East Asia and the Pacific. When individual countries are considered, Thailand, Cameron and Bahrain enrollment rates are among the highest, with increases of 16, 20 and 36 times, respectively. It is worth noting that tertiary enrollment rates have far outreached population growth of school-age children in all regions for both sexes.

Figure 2 - Tertiary Level Gross Enrolment Ratios

Source: World Atlas of Gender Equality in Education, United Nations, 2012

Figure 3 – Women Enrolment in Tertiary Education
Gender Parity Index Worldwide

Source: World Atlas of Gender Equality in Education, United Nations, 2012

Figure 3 shows gender parity index at the tertiary educational level in 149 countries. Results show that women now represent the majority of tertiary students in 93 countries, while men are the majority in 46 countries. A stronger participation of women in tertiary education has not necessarily led to an increase in employment in many sectors, including academia. This finding needs to be further explored by research. Worrisome are the blue areas in the world's map, which represent countries for which no data on women's representation in tertiary education is available. Lack of data imposes critical strategic and managerial limitations on program implementation, assessment and evaluation.

At tertiary educational level, many countries have comparable gender parity index: Central and Eastern Europe, Central Asia, North America and Western Europe. Central and Eastern Europe, Latin America and the Caribbean, and North America and Western Europe (***Figure 4***).

United Nations Institute has an interactive website, i.e., "Women in Science", where information on women's representation can be retrieved. Data on rates of Master's degree, Ph.D. degree and "researchers" is vastly missing in the developing world. Data has been summarized elsewhere[12].

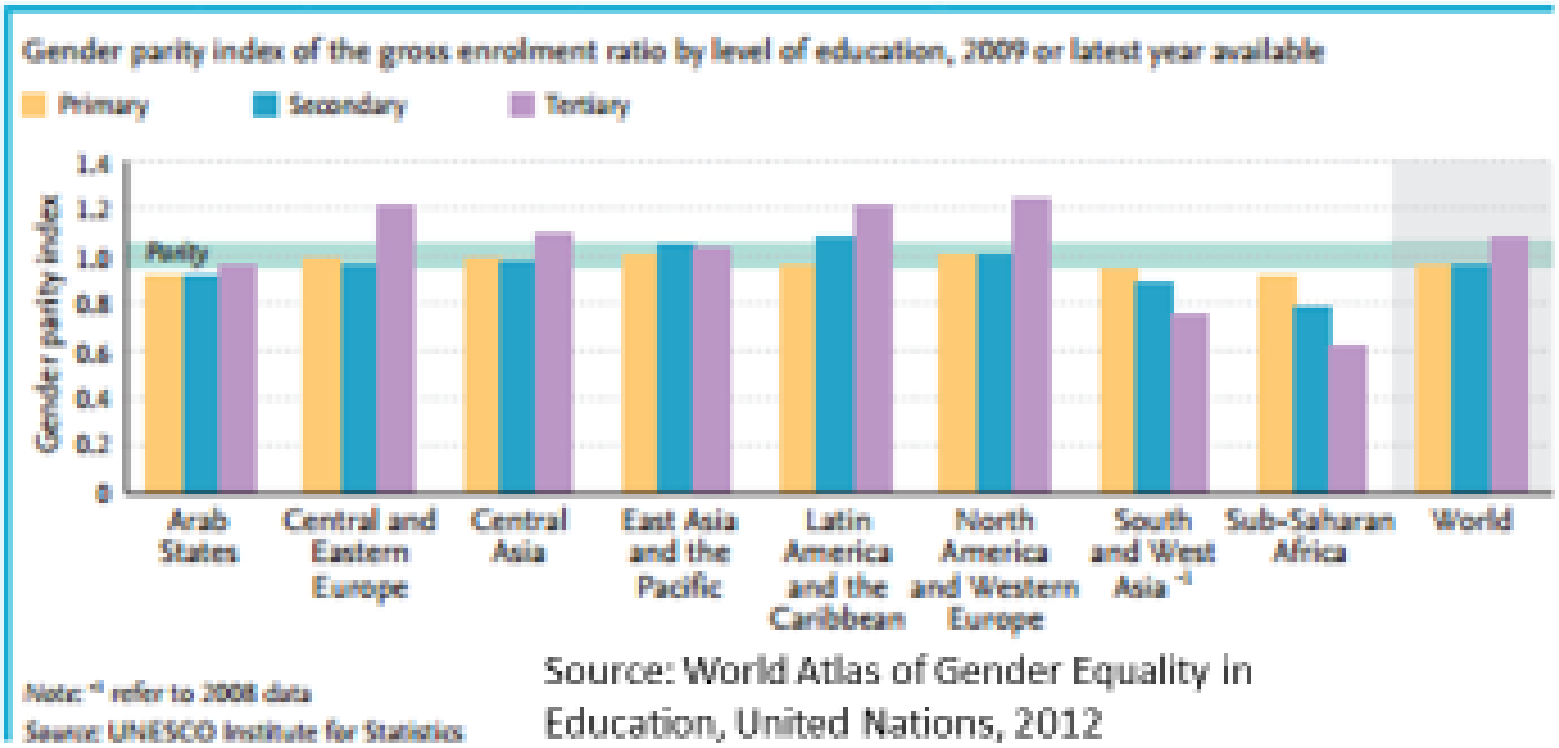
National wealth greatly influences men and women's participation in tertiary education. Countries with gender parity in the 0.97-1.03 range show high GDP per capita (Figure 5.3.1, *World Atlas of Gender Equality in Education, 2012*)[9]. However, there are a few exceptions to this, such as Japan (among the wealthiest countries), with a gender parity index (GPI) of only 0.88. This may be explained by a relatively recent advancement of women to university.

Table 6 describes succinctly the areas of progress and continued challenges in tertiary education.

Table 6 - Tertiary Education

Areas of Progress	Areas of Continued Challenges
- There has been major expansion of higher education in every region of the world in the past 40 years, from 32 million (1970) to 165 million (2009). - Women enrollment has grown almost twice as fast as that of men. - Since 1970, tertiary enrollment grew 24 times in Sub-Saharn Africa, and 17 times in the Arab States. -Enrollment rates in East Asia increased 15 times and are now the highest rates in the world. - Highest gross enrollment rates are seen in Bahrain (36 times) and Cameroon (20 times). - Shift from male to female dominance in enrollment is a function of changing societal and family attitudes towards girl's education. - Girls have now growing expectations and positive attitudes towards schooling. - Gains in enrollment have occurred worldwide. The largest gains have been seen in North America and Western Europe, Central Asia and Central and Eastern Europe.	Access to higher education is still a problem in many countries. - The highest enrollment rates have been recorded in regions that had the lowest levels of enrollment in 1970 and which continue to record modest enrollment levels to this day. - The largest male enrollment rates have occurred on Sub-Saharan Africa. - Overrepresentation of women in higher education is not yet associated with more jobs, especially those at leadership and decision-making levels. - Data using same parameters and definitions are hard to find. There is a great deal of heterogeneity in working definitions, such as researchers and scientists or in fields and sub-fields. - Gendered data by degree holders (Master's. and Ph.D.) clustered by fields and sub-fields is not available for a large number of developing countries. - Raw data (sample size) is only available at the UNESCO Institute of Statistics. - No statistical analysis has been carried to identify statistically relevant trends over time. Trends reported as "increase" may not be significant, making it harder to evaluate impact of gender equality interventions.

Figure 4 – Women's Participation in Primary, Secondary and Tertiary Education – Gender Parity Index of Gross Enrolment Ratio by Level of Education



Source: World Atlas of Gender Equality in Education, United Nations, 2012

Postgraduate Education

We have not been able to identify data for postdoctoral researchers. In a 2010 report (IFPRI Discussion Paper 00957) it is acknowledged that funds to send scientists abroad have dried out and that a large number of African countries have recently established postdoctoral training programs. However, these programs are very small and enroll few scientists[13].

Efforts need to be made to collect information worldwide to characterize the career transitions that follow the attainment of undergraduate and graduate degrees, especially in developing economies. In Africa, at least in the Agricultural Sciences sector, employment at research centers and higher education institutions can occur as early as the Bachelor's degree level. Worldwide data is needed to characterize education-to-employment to determine where resource allocation and career development training are most impactful. An inventory of challenges and opportunities will help develop strategies to promote hiring of women STEAM faculty at early stages in the academic pipeline.

Global Challenges of Tertiary Education: Public Investment – An African Example.

Patterns of public spending on tertiary education are quite different among high- and low-income countries. Public spending increases with wealth of countries (measured as a share of GDP or in per student investment). However, both groups, high- and low-income countries are experiencing an expansion in tertiary education enrollments.

Even though the outcomes of tertiary education, i.e., quantity and quality, may respond very differently to investments, as shown in a World Bank report, efficient spending is critical for the developing world. In the recent "2015 African Higher Education Summit"[14], it was recognized that the current $1 billion investment in African higher education will not support the development of a workforce predicted to represent 25% of the world's working segment in 2050. Dr. Patrick Awuah, founder of Ashesi University of Ghana, states that the investment in this region needs to be around $50 billion. It can be argued that the level of public investment in Africa is so low that it threatens the sustainability of the tertiary educational system. International action is urgently needed to revert this unfavorable scenario[14].

Worldwide Representation of Women with Advance Degrees

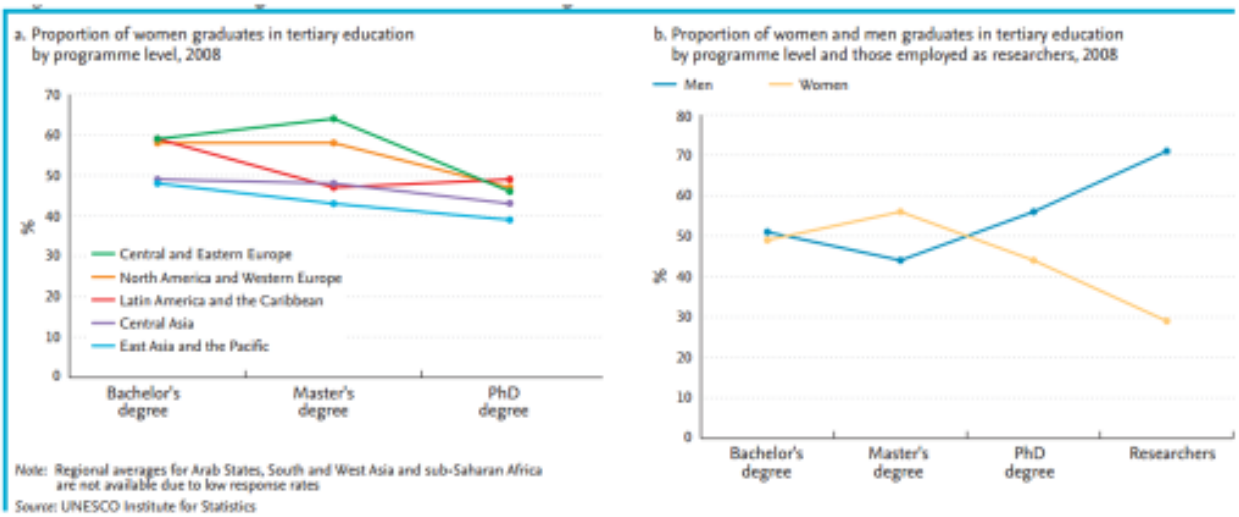
There are significant differences in the rates at which women and men pursue an advanced degree. At the bachelor's degree level, women have slightly surpassed men in three of the 5 world regions, with rates of 56% and 44%, respectively, However, this edge is lost at the Master's degree level, where women surpasses men in North America and Western Europe, and Central and Eastern Europe. Women with PhD degrees are disproportionately underrepresented in 4 regions, and are close to parity in Latin America and the Caribbean (***Figure 5, part a***). Based on degrees attained (and not employment status or rank), it is clear that women are being excluded from research careers after they attain Master's degree. Women's relative representation decline from ~58% to ~29% (***Figure 5, part b***), while men's representation increase from ~43% to ~70% during the same period.

The overall distribution of women researchers is represented in ***Figure 6***. Venezuela and Latvia have the highest proportion of female researchers in the world (55%), followed by Georgia, Philippines, Thailand, Argentina, Paraguay, and Uruguay. No information regarding researcher's academic rank is available for developing countries, making it difficult to characterize career progression. Such data is available for European institutions (which use grades A through C), which correspond to the ranking system in the U.S. (assistant, associate and full professor). Information on

professional ranking in academia is even further complicated by the academic track, with or without tenure. Consensus needs to be reached in how to establish corresponding nomenclatures which can consistently portrait types of appointments and career progression in academic institutions around the world. This information is critical to identify the most vulnerable transitions, when women may opt out of academia and research altogether.

Figure 5 – Proportion of Women with Advanced Degrees

Source: World Atlas of Gender Equality in Education, United Nations, 2012



Based on the current data set available, the decline of women's representation in the STEAM academic pipeline is a widespread phenomenon. Women face a series of cumulative disadvantages as they move up the educational ladder in research and teaching activities. There are a multiplicity of factors that contribute to this exit, which may have predominance in some but not all regions of the world. Overall, poor retention and career advancement rates for women are found associated with lack of clearly defined institutional policies governing promotion, access to resources and career development training. Factors found globally to impact retention and advancement of women include networking, mentoring and leadership coaching. A discussion on factors that lead to the exclusion of women in research is found in Table 10.

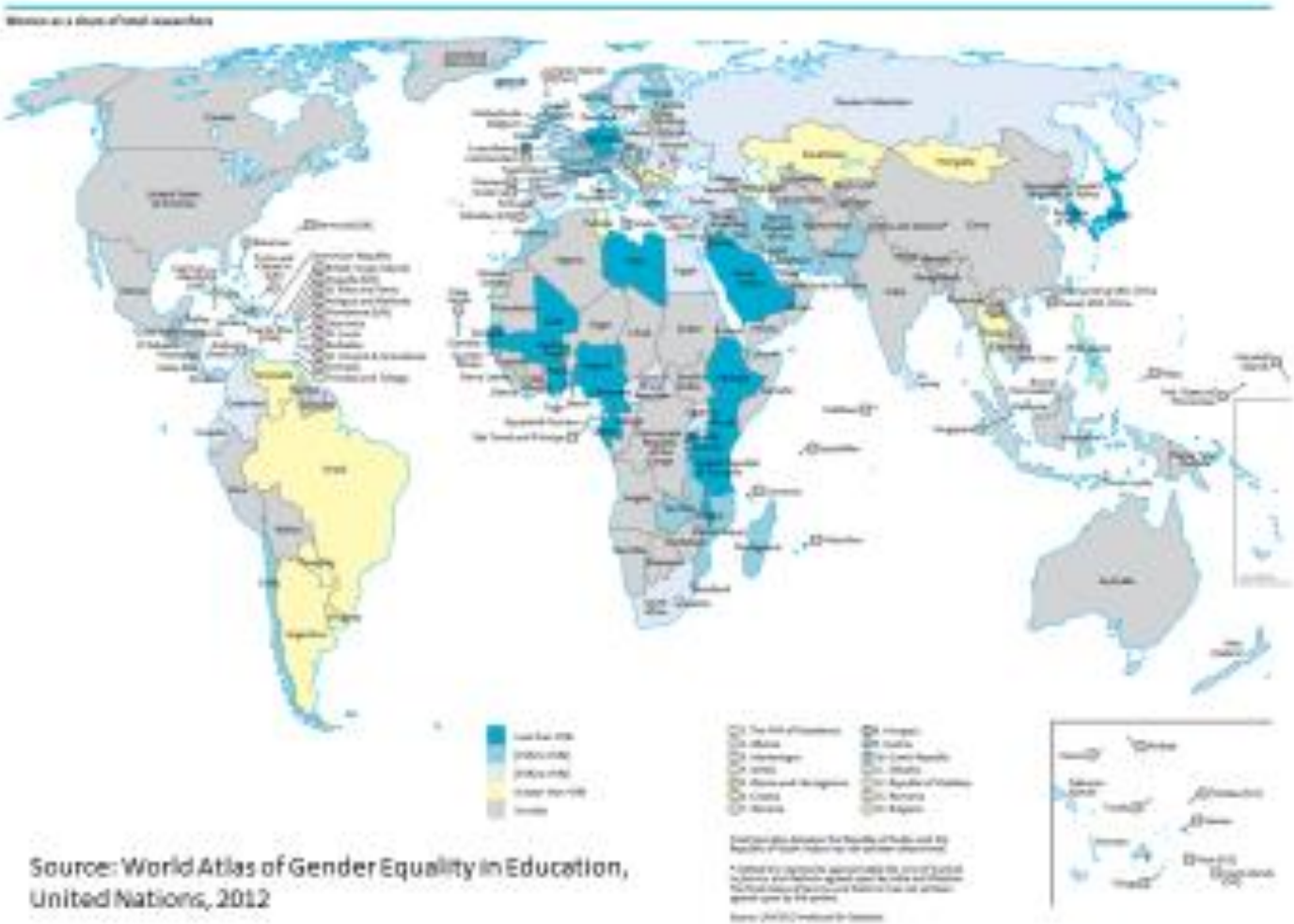
Horizontal Segregation: Women in Fields of Work

Even though women's enrollment in tertiary education is increasing worldwide, the representation of women in different fields of study is highly variable, with predominance of women in "soft sciences", such as life sciences and social sciences, and underrepresentation in Mathematics and Statistics, Computing and Engineering.

A recent 2012 United Nations report[9] analyzed gender differences in various fields of study and found that women suffer occupational segregation even in countries where they have achieved parity or represent the majority of graduates.

Females account for the majority of graduates in life sciences in Arab States, Central and Eastern Europe and Central Asia (***Figure 7***). In the extreme end of the spectrum is the representation of women in Computer Sciences and Engineering, where they account for less than a fifth of graduates. In Central and Eastern Europe, for example, women represent 70% of women graduates in Life Sciences, but only 29% of graduates in Computing[15]. In Central Asia, these rates are respectively, 68% and 39%.

Figure 6 – Worldwide Representation of Women Researchers



Source: World Atlas of Gender Equality in Education, United Nations, 2012

Figure 7 – Percentages of Women Graduates in the Fields of Science, Social Sciences, Business and Law by World Region (2008).

Percentage of women graduates in the fields of science and social sciences, business and law by region, 2008

Broad and sub-field / Region	Science					Social sciences, business and law				
		Life sciences	Physical sciences	Mathematics and statistics	Computing		Social and behaviour science	Journalism and information	Business and administration	Law
Arab States	**51**	73	61	59	33	**53**	69	58	42	55
Central and Eastern Europe	**47**	70	54	53	29	**61**	62	69	61	58
Central Asia	**53**	68	44	60	39	**41**	46	60	43	34
East Asia and the Pacific	**48**	60	58	62	29	**53**	56	64	52	51
Latin America and the Caribbean	**41**	67	51	53	31	**57**	70	61	56	52
North America and Western Europe	**40**	60	43	48	21	**57**	64	63	53	59

Source: UNESCO Institute for Statistics

Source: World Atlas of Gender Equality in Education, United Nations, 2012

Caution needs to be used when analyzing world regional data. Countries within the same region may display important differences in gender disparities, rendering regional interventions either unnecessary or highly needed. This is best exemplified by the current status of women researchers in Asia. Women's representation in sciences in Asia is as follows: Myanmar (86%), Philippines (52%), Thailand (51%), Indonesia (31%), Singapore (29%), and Pakistan (27%). Even lower rates are found in Bangladesh (14%) and Nepal (8%)[16].

Leaky Academic Pipeline in the United States

The current gender-based differences in the academic pipeline are very well documented in the United States. ***Table 7*** illustrates and example of the academic career progression in Biological Sciences. It shows the decline of women's representation in ascending career stages. Data was collected by the National Sciences Foundation (Table 9-23, 2013 for scientists; Table 9-27, 2013 for postdoctoral researchers; Table 7-4, 2012, for doctoral degree holders; Table 3-1, 2012 for graduate students; Table 5-1, 2012 for Bachelor's degree). Noticeable is the overrepresentation of women PhD holders (51%), which sharply contrasts with the number of women full professors (23.2%).

Table 7 – Example of Academic Pipeline in the U.S.

Career Stage	Female		Male	
	N	%	N	%
Undergraduate	59,217	59.3	40,683	40.7
PhD Graduate	4,152	53.1	3,665	46.9
Postdoctoral Fellow	8,787	43.8	11,299	56.2
Assistant Prof	6,400	46.1	7,500	53.9
Associate Prof	4,100	31.3	9,000	68.7
Full Prof	4,600	23.2	15,200	76.8

Source: NSF National Data, 2012, 2013[17].

A great deal of research has been carried out in the United States to identify barriers women face in academia. In 2002, an U.S. Senate Committee contracted The National Academy of Sciences to investigate the nature and extent of gender disparities. A thorough compilation of findings is published by the *National Academy of Sciences in 2009*[18]. Their findings are summarized in a later section.

Leaky Academic Pipeline in Africa and Europe

There have been very few publications addressing statistical data and/or factors contributing to the lower representation of women in STEAM careers at various levels in international research and higher education institutions worldwide.

In Africa, in particular, an example of the academic pipeline is best exemplified by the African Women in Agricultural Research and Development (AWARD), which encompasses 125 agricultural research centers and higher education institutes in 15 Sub-Saharan African countries. Data has been described in an IFPRI 2010 discussion paper[13].

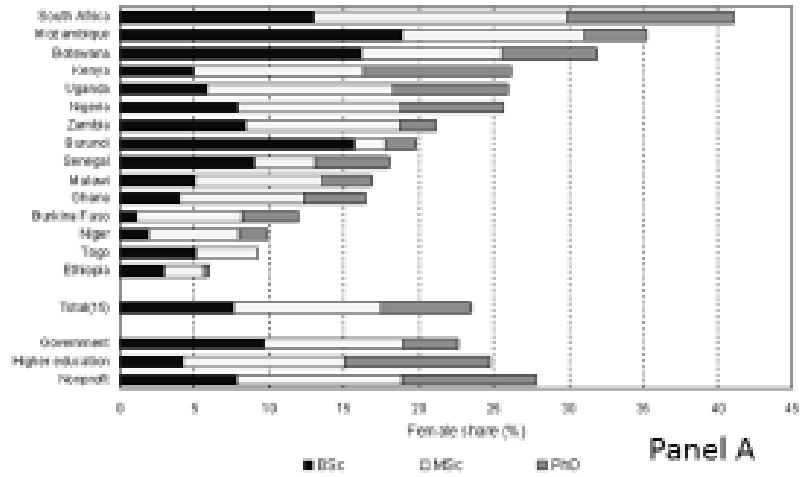
The proportion of female professional staff employed in agricultural research and higher education has increased from 18% to 24% in the 2000-2008 period. However, fewer women have advance degrees, compared to their male colleagues.

In the 2007-2008 period, the qualification level of agricultural researchers have declined: 2/3 of research personnel have only BSc degrees. A contributing problem is that many universities lack PhD programs or have small programs. It is not surprising that women with PhD degrees in Africa represent only 4% of all PhD graduates (***Table8)***.

Levels of female representation vary in different African regions, with higher values in South Africa, Mozambique and Botswana (32, 35 and 41%, respectively) and lower values in Ethiopia, Togo and Nigeria (6, 9 and 10%, respectively; ***Figure 8, panel A***).

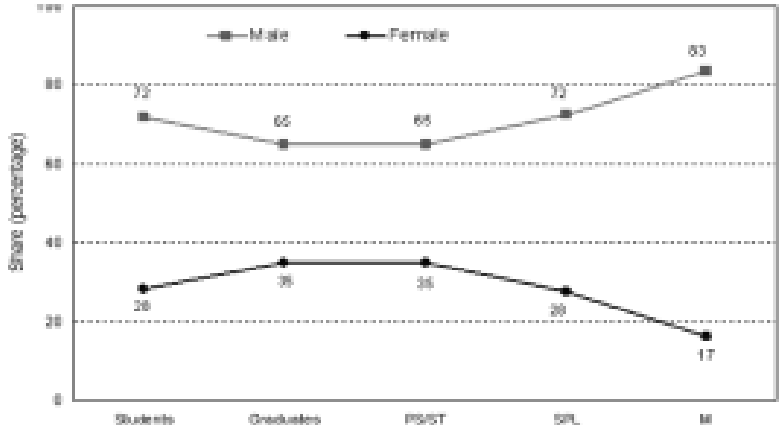
Figure 8 - Academic Pipeline for Women in Agricultural Sciences in Africa

African Women in Agricultural Research and Development (AWARD); Agricultural Science & Technology Indicators (ASTI); International Food Policy Research Institute (IFPRI)



Panel A

Source: Calculated by authors based on survey responses.



Panel B

Source: Calculated by authors based on survey responses.

Source: IFPRI Discussion Paper 00957, March 2010. Female Participation in African Agricultural Research in Higher Education: New Insights.

PS/TS – Professional and technical support staff.
SPL – scientists, assistant professors, senior lecturers not in management positions.
M – Management; directors, deans and department chairs.

The vertical segregation that characterizes the academic pipeline in the U.S. is also seen in Africa (***Figure 8, panel B***). The career progression from assistant professor/researcher/senior lecturer to manager/director/dean/department chairs involves an increase from 72% to 83% for men. For women, this transition involves a reduction from 28% to 17%.

Table 8 – Average Representation of Women in Agricultural Sciences by Degree and Institutional

Female Student Enrollment		Staff by Degree		Staff by Rank	
Bachelor's Degree	83%	Bachelor's Degree	26%	Associate Scientist	44%
Master's Degree	13%	Master's Degree	26%	Scientist	27%
PhD Degree	4%	PhD Degree	18%	Senior Scientist	19%
				Principal Scientist	11%

Source: IFPRI Discussion Paper 00957, March 2010.

ASTI data for the Caribbean show an important increase in the representation of women researchers in Agricultural Sciences in the 2006-2012 period. Women's rate increased from 23.2% to 39.2% in Dominican Republic, from 7.2% to 20.8% in Nicaragua and from 9.6% to 21.3% in Panama (www.asti.cgiar.org).

Table 8 shows representation of women in the student's body (measured by student's enrollment) and in the professional staff sector, segregated by degree type and academic rank. .

In Europe (EU-27), following international trends, women's representation in research has increased from 2002-2010, with a growth rate higher than men's. The largest growth rates occurred among women scientists and engineers, with an average of 5.4% per year, compared to a 3.1% rate for men. Despite larger growth rates for women in Europe, Science and Technology are still male-dominated[(15)]. Moreover, women represent the majority of researchers employed in Science and Technology (***Table 9***), but are not too far from parity in knowledge-intensive fields.

Table 9 – Average Representation of Women in STE in EU-27

Sector	% Women	Sector	% Women
Employment in S&T	53	Researchers in Higher Education	40
Researchers at Knowledge Intensive Activities	44	Researchers in Government Sector	40
Researchers in Total	32	Business Sector	19

Horizontal segregation is also seen in Europe, with women predominantly dominating Education (64%), faring well in Health and Welfare (56%) and Agricultural and Veterinary Sciences (52%). However, women are underrepresented in STEM (40% or less, depending on country. Portugal is an exception, where women represent 50% of the PhD graduates in Engineering and Construction, in contrast to 12% in Japan).

Women's promotion and advancement in Europe also suffers vertical segregation**.** ***Figure 9*** shows women representation in their ascension from positions equivalent to assistant professor (grade c), associate professor (grade B) and full professor (grade A).

Overall, women's representation is increasing in all fields of sciences in higher education, although at different rates and in different countries. Humanities and Engineering are attracting more women than ever before. However, larger gaps still remain in the government and private sectors. Regarding those, patterns are highly country-specific.

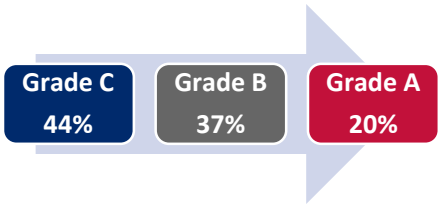


Figure 9 – European Academic Pipeline. Rates of women's representation in ascending hierarchy.

Factors Driving Women Out of Education and the Academic Pipeline

The progressive vertical and horizontal segregation of women in academia is universal. Rates of exclusion by rank or field of work vary widely in world regions. Even though most publications addressing the cumulative disadvantages women face in career progression, and the impactful interventions to mitigate barriers are American or European, there is consensus that many of the barriers are common among the developing and developed countries. ***Table 10*** provides an overview of the barriers affecting gender equality in education, in general, and in the academic pipeline. Some are country- or region-specific, while others seem to contribute globally to the underrepresentation of women in STEAM and other fields of work.

Table 10 - Examples of Barriers Affecting Gender Equality and Women Empowerment	
Global Factors: External	
Gender-Identity Challenges and Cultural Stereotypes	Cultural Capital
Overt Discrimination	Conscious and Unconscious Bias
Women's Disproportionate Domestic Care; Work-life Balance	Perception of "Women-unfriendly" Culture
Lack of Role Models	Solo or Token Status (lack critical mass)
Global Factors: Internal	
Lower Self-perception than Men	Lower Self-efficacy than Men
Lack of Sense of Belonging/Feelings of Isolation	More Prevalent "Impostor Phenomenon"
Local Factors Likely To Play a Role in Developing Countries	
Lack of Legislation and/or Compliance to Legislation Supporting Human/Women's Rights	
Sexual Harassment/Assault	Life in War Zones/Political Conflict
Lack of Career Development Opportunities	
Local Factors Likely To Play a Role in Developed Countries	
"Prove-it-again" (working twice as hard as men)	Gender "Tight Rope" (Women behaving more masculine to fit in)
Maternal Wall	Tug-of-war (Women competing among themselves)

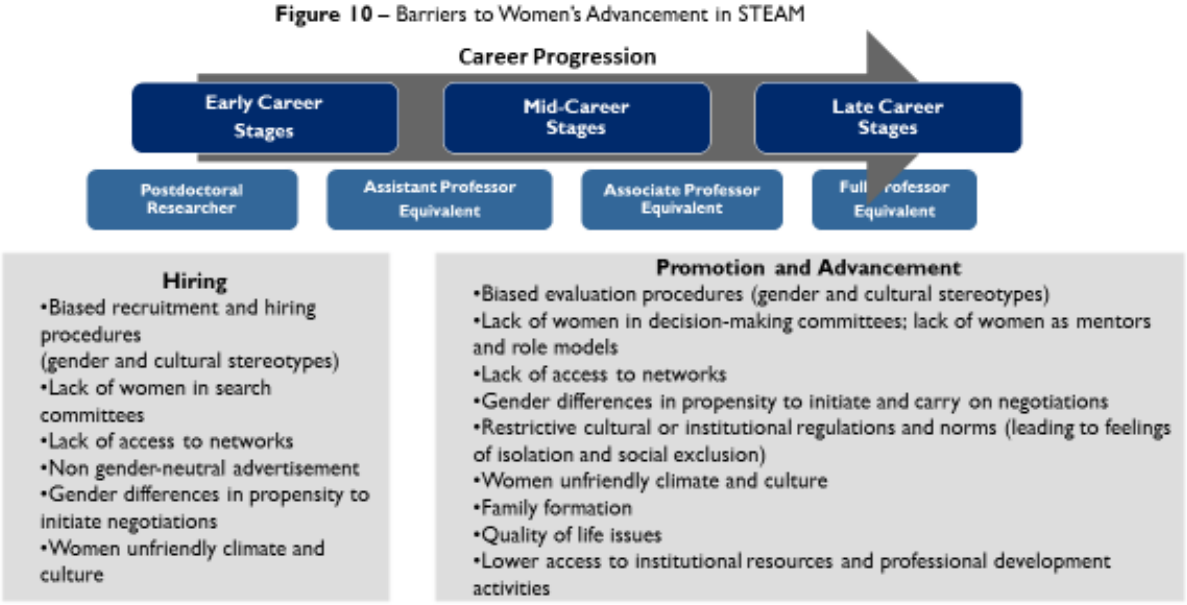
In developing countries, female scientists are subject to stronger cultural and societal barriers such as discrimination, overt sexism, lower access to education, unequal pay and funding, lack of contraception or reproductive choice, danger of sexual harassment and assault. Despite these obstacles, the executive director of the World Academy of Sciences, Romain Murenzi, reports a worldwide increase in interest in scientific research among women[19].

The "leaky" academic pipeline has been fully examined by research carried on by the U.S. Government and the private sector. ***Figure 10*** summarizes obstacles found to be relevant in the hiring and career progression of women working in STEM careers in the United States. These factors have been summarized from reports by the National Sciences Foundation (ADVANCE Program)[20], NIH[21], National Academy of Sciences[22] and Harvard University[23]. Most, if not all of these obstacles have been recognized by international organizations as equally important in the academic environment in developing nations alike.

A great deal of research and discussion has been devoted to gender bias (product of unconscious processes) as one of the key factors underlying gender disparities worldwide. Evidence supporting gender bias has accumulated from social and behavioral sciences. In a very clever research program in social sciences, Moss-Racusin and collaborators demonstrated that men are hired at higher rates, with higher starting salaries, even though selection was made from a pool of women and men with identical resumes[24]. Moreover, a survey of 1,300 female scientists *(AAAS, 2010)*[25] show that 52% of women said they had encountered gender bias in their careers, compared to 2% of men. Moreover, in Spain, men are 2.5 times more likely to rise to full professor than female colleagues with comparable age, experience and publication records[26].

Regarding internal factors, issues of self-perception, self-efficacy and sense of belonging are widespread and known to be associated with women's career outcomes. Women are more prone to

Figure 10 – Barriers to Women's Advancement in STEAM



experience self-doubt, indicated by the prevalence of "Impostor Phenomenon"[27], are more reliant on the quality of advisor-advisee relationship[28] and feel less fit for the rigors of academia[29].

Regarding cultural bias, the situation of women scientists in the Arab world seems to contradict our own cultural bias: Islam gives women the right to education, which results in forty percent of women attending university in Science, Engineering or Medicine[30]). These fields are perceived as "male-dominated" in other parts of the world.

Impactful Interventions – United States

The longest U.S.-funded program to investigate causes and determine best interventions for gender disparities is the NSF Advancement of Women in Academic Science and Engineering Careers (ADVANCE)[31]. A thorough analysis of interventions, their impact, outcome measures and policy implications is found in the book edited by Abigal Stewart, Janet Malley and Danielle LaVaque-Manty[20].

Based on literature review (NSF ADVANCE, the U.S. Senate-mandated research to the National Academies, AAAS policy documents and the National Postdoctoral Association recommended policies and practices - with focus on "Agenda for Change"[32]), four programmatic areas need to be considered as target for interventions for gender equality in academia. National Postdoctoral Association's policies and practices have been included because they are relevant for the transition from training to professional appointments at universities and research centers. They

constitute a valuable resource to address early career needs. These recommendations have been based on nationwide questionnaires.

Table 11 - Programmatic Areas and Summarized Interventions to Mitigate Gender Disparities and Increase Women's Representation and Empowerment in Academia		
Programmatic Areas	**Goals and Objectives**	**Interventions**
Institutional Transformation[33]	Increase Women Faculty's Effectiveness and Visibility.	Nominate Institutional Equity Advisor.
	Facilitate the Attainment of Individual Career Goals.	Provide Training to Faculty/Admin Staff to overcome strong cultural and gender stereotypes.
	Orient Women Faculty to Know and Adjust to Organizational Culture.	Promote Presence of Women Faculty in Department/Division Committees/Increase Women's Roles in Leadership Positions.
Mentoring and Coaching[34]	Assist Women Faculty in their Professional Development Through the Guidance and Support of Experienced Faculty Members, who Serve As Role Models, Advisors and Advocates.	Financial Support, Sponsorship, Workshops, Mentoring Networks, Mentor Dyads or Groups, Life Coach.
		Scientific Review (Critiques to grant writing and publishing, others).
	Enhance Research Productivity and Academic Stature of Women in the Academic Environment.	Development of Leadership and Negotiation Skills Through Mentoring and Training Workshops.
Networking[35]	Promote long-term Institutional Changes Needed to Improve Faculty Retention and Advancement	Hot Networks (Productive Teams)
	Increase Social Capital.	Network of Women Faculty to Gain Access to Resources, and Promote Institutional Change.
Career Development	Provide Stage-Specific Career Development. See Figure 10.	Workshops, Attendance to Scientific Meetings, Access to Resources, Funding, etc.

Four programmatic areas and examples of validated interventions are listed in ***Table 11***. Interventions have been tested and validated by research funds from NSF ADVANCE[36].

Career development has been found to be critically important in improving the underrepresentation of women in all fields of work. At different career stages, women need to acquire and develop a new set of skills and abilities. Concomitantly, they need to gain access to positions of decision-making power and leadership. Career development needs and interventions aimed at different stages are described in ***Table 12***. They have been proven successful by various methods of program assessment and evaluation metrics. The source of these validated strategies is listed below the table (Table 13 has separate references at the end of the bibliography section).

Table 12- Career Development
Strategies to Increase Hiring, Retention and Advancement of Women in STEM

Early- to Mid- Career Stages	Mid- to Senior Level Stages
Based on NPA Postdoctoral Core Competencies • Discipline-specific conceptual knowledge • Research skill development • Job hunting, interviewing skills, self-promotion and negotiation skills • Communication skills • Professionalism • Leadership and management skills • Responsible conduct of research **Based on NSF ADVANCE, NAS, Others** • Conflict management and resolution skills • Styles of interpersonal interactions and leadership skills • Self-assessment and mentoring plan • Collaborative problem-solving skills • Cultural competence: Working in a diverse environment; cross-cultural communication skills	• Access to information, resources and collaborations that meet research needs • Writing and publishing (grants, paper, etc.) • Budgeting • Personnel management - Creating an environment of inclusion • Building collegial and mentoring relationships • Adapting to workplace climate, institutional organization and culture • Planning career advancement strategies • Time management skills (work-life balance) • Strategies to solve institutional problems • Skills for higher academic administrative roles • Understanding tenure and promotion policies and processes • Leadership and executive training • Information networking, intra- and inter-institutional programs • Making effective public presentations

Shifts in Gender Identity and Cultural Stereotypes Are Needed in All Interventions

Gender identity and cultural stereotypes are an overarching theme, central to the participation of women in society at large, as well as in STEAM. They constitute one of the most significant barriers women face worldwide, but are more prevalently in developing nations. They affect young women's and girl's career choices and opportunities. Initiatives in all target areas need to help women and girls acquire a new socio-cultural and gender identity. This concept has been very well articulated by U.N. Women Deputy Director and Assistant Secretary-General Lakshmi Puri:

"The phenomenon of gender stereotypes needs to be countered and fought in multiple areas: in languages and vocabulary, laws and practices, mind-sets of people, justice systems, media and education, in different organizations and public authorities, in enterprises, and in individuals."

In the next sections we provide a few examples of impactful interventions (some are evidence-based, some are modeled after evidence-based) in 5 areas: 1.) Institutional Transformation: Gender Quotas, Equity Advisors and Women-championing Men' 2.) Mentoring and Coaching – Online Mentoring to Empower Women Worldwide; 3.) Networking and Capacity Building in STEAM; 4.) Women's Empowerment and Political Engagement; and 5.) Ending Violence against Women and Girls (VAWG)

Institutional Transformation: Gender Quotas, Equity Advisors and Women-championing Leaders

Correcting gender inequalities in academic careers is complicated, due to the time it takes to compensate for historical gender inequalities, and the length of time spent in each stage of the academic career (from years to decades) As such, changes in hiring practices or improvements in retention may have a delayed impact, resulting in a long time lag before effects or changes can be

seen. This is referred to as demographic inertia. Mathematical modeling has been used to discriminate inertial effects from gender-bias, as well as predict time needed to achieve gender parity[38]. Based on geographic inertia and the lengthy stages of the academic career, it is clear that gender equality efforts need to be approached aggressively, if impact is desired and expected within a decade. A way to expedite woman's participation is to set gender quotas, which result in faster changes in gender imbalances, thus minimizing demographic inertias. But gender quotas require a top-down approach.

Commitment to promote organizational change has been identified worldwide as a key element in bridging the gender gap. Institutions, i.e., government, academia and private sector, need to take full responsibility for developing strategies to attract, hire, promote and advance women to leadership. Quotas as a policy instrument may be controversial in environments such as academia, where merit predominates. But current merit systems seem to favor men over women. A review on the use of gender quotas provide insights into the positive and negative impacts of quotas[39].

More than half of the countries in the world have implemented some type of political quota, mostly in the last twenty years. They have led to a dramatic increase in female leaders across the globe. In Belgium, for example, women's political representation jumped from 12% to 36.7% in the course of just a few elections, following the introduction of the legislation. Quotas have increased female leadership and have influenced policy outcomes[40].

In academia, a common practice has been to establish a minimum gender quota in committees involved in faculty hiring and promotion. The minimum percentage of women (or any set of minority individuals, for that matters) necessary to make a difference in a committee is unclear, but frequently estimated to be 30%. (often referred to as "critical mass"). This is when minorities achieve membership status and become more able to express their opinion and concerns, without the fear of being rejected by the dominant group. A study from Spain[41] found that the gender composition of evaluation committees was relevant when selecting for full professor positions, but not for associate professor positions: the presence of one woman in a committee of seven members was enough to increase the number of women promoted to full professor.

A successful example of gender quota is the South African Research Chairs Initiative[42] (SARChI), sponsored by the National Research Foundation of South Africa. Forty two new chairs have been dedicated to women in South African research institutes. A positive downstream effect is the increase of women role models, an effect that has the potential to impact the number of women-championing men.

Regarding institutional transformation, the nomination of gender equity advisors and women-championing men have been shown to improve gender equality in academia. Stepan-Norris and colleagues at University of California Irvine showed that institutional-nominated equity advisors have an influencing role in the percentage of women hired. Advisor's role was assessed by level of effort and specific actions such as time spent in discussions with department chairs, deans, participation on hiring committees, mentoring women, among others[43]. The utilization of equity advisors is commonly found in recommendations from international organizations (U.N., World Bank, IADB and OECD).

Another important strategy in gender equality is men's involvement. Research addressing cultural forces that determine men's support (or lack thereof) of gender initiatives provided important insights about information and skills needed to effectively communicate with and engage men. Men can be powerful agents for change, especially with other men who are not fully "on board" with inclusion efforts. A recent review discusses the "the making of men champions for gender inclusion", with testimonies of women's champions such as Ronald C. Parker, senior vice president of PepsiCo and chief diversity and inclusion officer[44]. The higher men's awareness of gender bias, the more likely they are to feel that it is important to achieve gender equality.

No studies addressing the implementation and impact of men championing women could be found at this time. However, its potential power in promoting cultural change, locally and globally,

cannot be understated.

Mentoring and Coaching – Online Mentoring to Empower Women Worldwide

Research and higher education institutions are investing in their human capital through programs that enhance participant's personal and professional development. Mentoring and networking are helping women succeed particularly in the early and mid-career stages. In later career stages, leadership development is improving women's individual performance and enhance leadership effectiveness.

Mentoring has been recognized as one of the most impactful strategies to mitigate gender disparities in all educational levels. NSF ADVANCE-sponsored research findings strongly support mentoring as key in academic career development for women[34]. Mentoring is being used worldwide as toll for career advancement. Below we discuss examples of highly replicable, scalable, sustainable and cost-effective programs that provide women and girls in developing nations with knowledge-based training and mentorship.

The gender gap in internet access worldwide is severe: more than 200 million fewer women than men have access to internet in developing countries. To help close this gap, U.N. Women, in collaboration with Facebook's "EmpowerWomen"[45] has developed iLearn[43], a global mobile-learning platform for and by women entrepreneurs. iLearn offers women cell phone/smart phone users learning resources, webinars, online courses and other curated materials to empower women's economic development. Learning takes advantage of "storytelling" model. One particular module, "Behind the Business Plan" received a SEED award[46].

Another successful example of a worldwide network of women is the Earth Science Women's Network[47]. This organization provides career development, peer mentoring and community building for women in Geosciences across the world, from upper undergraduate level to professionals and scientists. ESWN started in 2002 with funds from the American Geophysical Union. They have now about 2,000 members from 50 countries.

Regarding coaching, "Leadership beyond Boundaries" is an intensive executive leadership program offered by the Center for Creative Leadership to leaders worldwide. Programs are portable, scalable, simple and available in a variety of languages. Recently this program was offered free of cost to 18 African leaders (African Women Leader's Program) [48]. Donations help offerings to women worldwide. This is a successful model that can be replicated in large scale.

Networking and Capacity Building in STEAM

On a global scale, it is possible to provide women and girls with training to develop appreciation for STEM, especially in fields of study where women continue to be significantly underrepresented. Tested and validated curricula can be packed as "learning kits" and be easily and inexpensively implemented by institutions around the world, as exemplified by Microsoft Global Women's Hackathon. This initiative is successfully raising women's and girl's interest in computer sciences worldwide[49].

The MEPI-sponsored Women in Technology is serving women in the Middle East and North Africa (The U.S. Middle East Partnership Initiative, co-sponsored by Microsoft and Institute for International Education). Since 2005, this network has provided training in information technology, professional development, and entrepreneurship to over 10,000 women from underserved communities[50].

Yet another example of the powerful use of a "digital community" is STEM Camp for African Girls on Robotics and Renewable Energy, an initiative of Working to Advance STEM Education for African Women Foundation (WAAW)[51]. Up to today, 62 girls have participated in STEM camp.

WAAW offered programs to 10,000 college secondary-to-college girls, trained 120 college fellows and awarded 17 college scholarships.

At a more senior level, the European Platform of Women Scientists provides 12,000 women in 40 countries with 100 digital and real networks[52].

Regarding information and best practice sharing, GenderInSITE builds partnerships to develop country-specific, evidence-based initiatives and training workshops, including gender and cultural stereotype reduction workshops. Current members include countries from Latin America and the Caribbean and East and South Africa regions. Gender-oriented interventions have the potential to impact hiring, retention, promotion and advancement to leadership. GenderInSITE is sponsored by Gender Advisory Board of the U.N. Commission on Science and Technology for Development (UNCSTD), University Twinning and Networking Program UNITWIN), Organization for Women in the Development World, Swedish Government (SIDA), The World Academy of Sciences (TWAS), Women in Global Science and Technology (WISAT), African Center for Technology Studies (ACTS), Chinese Academy of Sciences, and The Elsevier Foundation[53].

The impact of these initiatives is hard to determine at the present moment. Information on how training leads to employment is not publicly available.

Women's Empowerment and Political Engagement

The advancement of women to leadership positions in academia is improving, but is occurring at an exceedingly low pace. According to the Chronicles of Higher Education, only 1 in 4 college presidents are women[54]. In South Asian institutes for higher education, for example, women represent professors and deans at the following rates: Sri Lanka (24.5%, and 8.9%, respectively), Pakistan (19.7% and 8.5%, respectively), India (18.5% and 19.7%, respectively) and Bangladesh (12.3% and 5.6%, respectively). In Australia, women represent 43.6% of senior lecturer but only 29.9% occupy higher positions. In Europe, women represent only 18% of full professors[55]. Research needs to be carried out to help understand how gender differences are produced and maintained by organizational practices and social structures.

The participation of women in parliament worldwide has nearly doubled in the last twenty years. Wide variations can be seen across world regions and across chambers. In August 2015, women rates in decreasing order in both houses are as follows: Nordic countries (41.1%), Americas (25.5%), Europe (excluding Nordic countries; 24.4%), Sub-Saharan Africa (23%), Asia (18.4%), Middle East and North Africa (17.1%) and Pacific (15.7%)[56]. The biggest gains in women's representation during the last 20 years have been in Rwanda (60%), Andorra (46%) and Bolivia (42%). The number of male-only parliaments has also dropped, from 10% to 5%.

Through U.N. Women's programs, women political candidates are offered training to help build skills and capabilities, receive civic education and sensitization campaigns on gender equality. Since its implementation in 2007, "Chapeu de Palha Mulher" (Women's Straw Hat), sponsored by U.N. Women and Brazilian Pernambuco State Government, has reached nearly 100,000 women in 89 cities in North-Eastern Brazil, providing training in human rights, citizenship, and in Brazilian constitution. Women are offered a small stipend and childcare. Training is mandatory for skill development, networking and community support. This initiative has promoted important gender stereotype changes in the local culture. Women now participate in folklore festivals, which were originally exclusive to men[57].

Ending Violence against Women and Girls (VAWG)

Millions of women and girls around the world are victims of gender-based violence. Their lack of safety reduces their freedom, participation in schools, work and public life, with negative impacts on their health and wellbeing, and enjoyment of life.

Through partnerships with local and national government, women's groups and other partners (UN-Habitat, Women in Cities International, the Huairou Commission, Women and Habitat Network of Latin America and the Caribbean, and 80 other global and local partners), Safe Cities Global Initiative[58] developed comprehensive strategies to strengthen action against sexual harassment and assault, develop social protection schemes and adopt safety audits to guide urban planning in many cities around the world. Overall program impact has not been reported yet.

Another form of violence against women is emerging. Cyber VAWG is now recognized as a systemic societal challenge, as more women around the world gain internet access. It includes hate speech, hacking, identity theft, online stalking and uttering threats. Internet can also facilitate other forms of violence, such as trafficking and sex trade.

In 2013, the gender gap women/men in internet use in developed and developing world was 74%/80%, and 29%/33%, respectively[59]. About four billion people have internet access around the world. About 73% of women worldwide experience abuse online. In Europe (EU-28), 18% of women have experienced internet violence since the age of 15, which corresponds to about 9 million women. Women ages 18-24 are at a heightened risk of being exposed to cyber VAGW[60].

The UNESCO Broadband Commission Working Group on Gender Objectives for Digital Inclusion proposes to empower women and girls through digital literacy and skills building training, to develop gender-sensitive applications to monitor violence against women, and to protect them when they go online. It is also planned to make technology training and jobs more appealing to women and girls worldwide. Combating cyber VAWG will require a multinational, multi-level approach. Policies and practices, sanctions and compliances are available elsewhere[60].

Evidence-based Gender Equality and the genSET Model of Convergent Best Practices.

Country- or region-specific data is essential to help identify key barriers and design institutional gender action interventions. One initiative in particular, genSET (not in Table 14) developed a sustainable and replicable approach to improve academic excellence through the promotion of dialogue on gender. With funds originally from the European Commission FP7 Programs, genSET built networks of European science leaders, stakeholder institutions, gender experts and scientific leadership to help implement customized, effective gender equality strategies. Even though its EC funded phase was completed in March 2012, another initiative has sprung from genSET, Gender Summits.

Gender Summits are extending the concept of network building by organizing region-specific forums to promote gender mainstreaming into evidence-based, gender-oriented initiatives and policies. Activities include consensus seminars and recommendation reporting, capacity building workshops directed at hiring, retention and assessment of women's excellence in sciences, and valorization symposia (currently only in Ireland and Poland)[61].Gender Summit panels typically consider evidence from 120 research reports, which are revised by gender research experts, and use data from 100 European science institutions across 10 different sectors (universities, research funding institutions, pan-European associations, science journals, others).

Gender Summits and recommendation reports are essential to provide tools to develop institutional gender action plans, help identify key barriers to its implementation at the community/region/country level. This is a great model because it capitalizes on local knowledge and organizational support to implement and subsequently monitor strategy outcomes. International organizations are benefiting from participating in Gender Summits have been carried on in Africa and Americas.

Important Challenges: Data, Data, DATA.

Developing evidence-based interventions and policies is a difficult process in developing nations. Data reporting is not a common practice. When data is available, quite often it does not conform to international standards. Commonly used standards are essential to build national robust statistical capacity. Harnessing the benefits of statistical integration requires investments in the collection of internationally comparable sex-disaggregated statistics and the use of a variety of indicators to capture the complex economic, societal and cultural environments across regions and countries.

As it currently stands, data related to the underrepresentation of women in STEAM careers, working in research or higher education institutions, are insufficient to fully characterize the extent of their exclusion at any point of their careers. Research on the barriers women face in developing world is sparse, if not completely inexistent. Women's concerns and needs at different career stages, as well as their most vulnerable career transitions are mostly undetermined. The only field of activity for which robust data are available in developing economies is Agricultural Sciences. Data on other fields and sub-fields are hindered by inconsistent attributes of professional ranks and loose definitions of career stages, as well as varying clustering of fields.

Another source of problem concerns the terminology that defines scientific employment and fields of activities. A description of findings from She Figures (2012) exemplifies the heterogeneity and inconsistent of professional role definitions: "EU-27 women on average make up just 33% of the population of researchers and 32% of all employed scientists and engineers." In the U.S. the distinction between researcher and employed scientist is allusive.

European Union grades academic ranks as grades A through D. Grade C-academic staff is referred to as the first grade/post into which a newly qualified PhD graduate would normally be recruited. Information on postdoctoral researchers are not easily identifiable as a separate group, making it hard to determine their rates of employment in various sectors, and the transition training-employment.

Regarding fields of activities, the European Commission reports data on researchers in the higher education sector in areas such as Natural Sciences, Engineering and Technology, Medical Sciences, Agricultural Sciences, Social Sciences and Humanities (She Figures 2012). OECD reports data on Sciences, Education, Arts and Humanities, Social Sciences, Business and Law, Engineering, Agronomy, Health and Social Sector, and Services. UNESCO reports data on Sciences (Life Sciences, Physical Sciences, Mathematics and Statistics, Computing) and Social Sciences, Business and Law (Social and Behavioral Science, Journalism and Information, Business and Administration, and Law).

Statistical data to characterize a typical academic pipeline in the developing world, in fields such as Sciences, Science and Technology or STEM, from undergraduate, graduate, postdoctoral researchers, and researchers with appointments equivalent to the American rank (assistant, associate and full professors) cannot be found in recent reports (last 5-8 years) from World Bank, UNESCO, Inter-American Development Bank, OECD. Excellent data was found on research in Agricultural Sciences worldwide (ASTI).

Relevant, internationally comparable sex-disaggregated statistics are essential. The current lack or heterogeneity of data and lack of statistical analysis are rendering design, monitoring and evaluation of evidence-based initiatives to mitigate gender disparities in STEAM areas. Efforts needs to be intensified to encourage and accelerate the use of international, standardized statistical indicators to allow cross-country comparisons and progress over time.

The U.N. Secretary General's Independent Expert Advisory Group on the "Data Revolution for Sustainable Development" acknowledges the seriousness of this scenario and is developing joint efforts to overcome differences in capabilities and resources devoted to basic data collection, compilation and analysis. For competing sources of data, data curation needs to be undertaken to produce the most reliable data and to discard data that does not adhere to international standards.

In closing, there is a global consensus on the importance of public action on gender equality. Reliable, well-structured data is needed to understand the career progression of women working in STEAM fields in research and higher education institutions in the developing economies. Research findings and data on the academic "leaky pipeline" from U.S. and European institutions can be a valuable framework of reference; however insights and understanding of complex socio-economic and cultural determinants that are driving women out of the STEAM academe and workforce in the developing world are much needed.

Review Methodology

This report aimed to evaluate the present status of gender equality initiatives in academic research in the fields of Science, Technology, Engineering, Agricultural Sciences and Mathematics (STEAM) in Africa, Euro-Asia, Southeast Asia, Latin America and the Caribbean. The underlying objectives to achieve that aim can be described as follows:

- Provide evidence base for existing gender gap in STEAM globally
- Identify how gender gap changes at increasing levels of seniority within each STEAM field
- Compile data in academia to provide further granularity that may be useful in explaining trends in women's participation and retention in STEAM fields
- Review integrated STEAM programs , their draw for women, and how this might translate to integrated programs in other countries where resources are tight
- Identify challenges women face to enter and remain successful in STEAM fields, including different forms of gender-based violence
- Highlight successful programmatic practices to support women to thrive in STEAM fields

The process involved in this literature search involved multiple tiers. The first tier involved identifying data sets available that are directly or indirectly related to gender equality. Primary sources were UNESCO Institute of Statistics, World Bank, Inter-American Developing Bank, International Food Policy Research Institute, European Commission and National Sciences Foundation (U.S.). Reports from World Bank, UN Women, EC, NSF and their cited bibliography were the second tier. I had previously worked characterizing the academic pipeline in the U.S. and knew important publications that unraveled factors that impact women's hiring and progression through the academic pipeline; I also knew interventions to mitigate gender gaps in academia, many of them validated under NSF-ADVANCE funding. It was important to verify if American (or European) factors and interventions were local or global, so the forth tier was to identify publications and reports addressing those issues. A fifth tier was to look for interventions that have been implemented both in the developing and developed countries, with broad scope, high number of regions or people served and with high throughput processes (we-based). The selected programs fitted the description of scalable, replicable, cost-effective and sustainable, according to what we have been sked to deliver.

We included in this report information on the status of primary, secondary and tertiary education. They are relevant to graduate and postgraduate education and employment, as they represent preceding steps in the education-employment life cycle. Enrollment rates help the identification of vulnerable educational transitions. Looking at gender gaps in primary and secondary education may provide insights on when to design early interventions to raise curiosity and interest among girls and women in pursuing male-dominated fields.

We prepared a background section on women as integral part of labor force to identify general trends in women's socio-economic, political and cultural status in world's regions. They go hand-in-hand with access to education, health and wellbeing.

Reports from World Bank, U.N., OECD and I.L.O. were the primary bibliographic source for women's employment rates, primary, secondary and tertiary enrollments.

The section on gender equality in primary and secondary education represents an important gender gap inventory to identify cumulative disadvantages girls and young women face, which result from socio-economic and cultural barriers, among others.

Regarding postgraduate education, there is very little information available on programs outside Europe and U.S. There is no information on degree-granting institutions, fellowships and grants, and corresponding assessment of training programs (and reputation) for developing countries.

Number of students enrolled in Masters and PhD degrees is available but it is not broken down by field. Regional data has not been compiled and normalized for population size. There is no statistical analysis to determine trends in gender equality rates over time, making .it difficult to recognize trends above the population growth. For developing countries most of the information is either unavailable or incomplete.

Information on employment as "researcher" is available in the interactive site "Women in Science" (UNESCO) for many countries, in varying timelines between 1997 and 2013. This data has been generated by UNESCO. No distinction regarding academic rank, or type of degree is available for researchers, making it difficult to assess career progression. Gender rates are available for researchers employed at public and private sectors and academic institutions; however, the number of countries for which this information is unavailable is still very large.

A model of a gendered academic pipeline using U.S. data from the National Sciences Foundation was built. The career path includes undergraduates, PhD graduates, postdoctoral researchers, assistant, associate and full professors. This pipeline was used to illustrate the progressive exclusion of women as they ascend in academic rank, a phenomenon that has been reported in European countries (where data is available).

A model of academic pipeline was built with data from an African Consortium (AWARD/ASTI and IFPRI) for Agricultural Sciences. The declining trend can also be seen in a shorter academic pipeline (Bachelor's, Ph.D., and researchers), available at UNESCO's Women in Science. Information is not available for many countries. For reference, review blue areas in Figure 6.

Combining research findings in the U.S. and Europe, we created an inventory of the most common obstacles women face at different career stages in academia worldwide (summarized in Table 10 and Figure 10).

In this literature review, we analyzed a large number of interventions to increase the hiring, retention, promotion and advancement to leadership of faculty women. Interventions were divided in four programmatic areas: Institutional Transformation, Mentoring and Coaching, Networking and Career Development. Table 11 lists goals, objectives and examples of intervention targets.

We expanded Career Development in Table 12. Strategies addressing career development at early career stages were modeled after the National Postdoctoral Association's recommendations and policy papers, and NSF ADVANCE research findings. Mid- career development and advancement to leadership strategies were modeled after NSF ADVANCE. All career development strategies, without exception, described in Table 12 constitute recommendations found in reports from UNESCO, OECD, and European Commission. This fact reflects the universality of their rationale and, in most instances, in documented impact.

We wanted to take inventory of interventions that concern the participation of women in research and higher education institutions in Science, Technology, Engineering, Agricultural Sciences and Mathematics (STEAM), with focus on scalable, replicable, and cost-effective programs. The question we wanted to answer was "what is working?" To reduce the complexity of the answers, we analyzed five areas of interventions, shown to have impact locally (U.S) and globally: a.) Institutional Transformation; b.) Mentoring and Coaching, c.) Networking and Capacity Building in STEAM Fields, d.) Women's Empowerment and Political Engagement and e.) Ending Violence against Women and Girls (VAWG).

One very important setback of our bibliographic research is the lack of gender equality interventions with demonstrated effectiveness. Impact indicators have been developed across almost all social sectors. However, there is a consensus on the critical problems with sex-disaggregated data worldwide, but more specifically in developing countries.

Indicators to measure investment impact focused on gender equality in workplace, academia or not, are not being widely used or even agreed upon. Lack of standards in data parameters, data collection methods, data curation, shared data analysis tools are among the most common problems. As such, our criteria for selection of "best practices" was based on screening the literature for

interventions in the developing world with large target population, for example, those making use of virtual networks (high throughput outreach); knowledge-based interventions that result from collaborative efforts between "knowledge partners" (or those that have a potentially validated solution, such as tested training curriculums, for example) and community-, sector-,region- or country-specific partners (or those familiar with the size and scope of the problem).

Reaching a critical mass is important to encourage women's participation, especially in circles of leadership. Equity advisors have been widely used and there is research showing a quantitative impact on hiring and promotion of women faculty. A third intervention, women-championing men, has anecdotal evidence, and the potential to cause a broad and significant impact on cultural and gender stereotypes. Equity advisors and women-championing men share some common roles, but they are not the same.

Mentoring is recognized in peer review journals and reports by U.N., World Bank, as the most simple and yet effective intervention to increase the retention of women in academia. Web-based mentoring/virtual mentoring is highly scalable and replicable, and can be used to target women faculty at any level even in remote locations.

Regarding networking and capacity building, we chose to report on interventions to raise the interest of women and girls in areas where they are significantly underrepresented, such as information technology/computer sciences and robotics, as well as those that provide women with short-term training and high employability (technical level IT).

Regarding women empowerment and political engagement, as well as violence against women, the role of community engagement is critical. There are more indicators for program assessments in this area: number of women with political appointments, number of women attending education and training against violence and subsequent reduction of crimes against women. The literature on women occupying senior leadership in academic environment is sparse. The few rates available are discouraging. More data is needed in this area.

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