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Investing in women as drivers of growth: A gender-based assessment of the Science, Technology and Innovation ecosystem in Uganda

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ABSTRACT

The Uganda Science Education Policy of 2005 made the study of Physics and Chemistry compulsory for O-Level secondary school students in addition to Biology, English and Mathematics. While both males and females are equally represented in science courses at the early ages of school, the representation of women in science disciplines reduces with increasing levels of education and professional responsibility. Enrolments in sciences at the upper secondary school level constitute only about 20% of the total enrolments. Only 16% of the boys and 14% of the girls completing primary school got to attend secondary school. Girls constituted 44% of enrolments at secondary level, 25% in post O-level institutions and 35% in tertiary level institutions in 2000. The proportion of girls steadily increased to 46% in secondary, 41% in post O-level and 44% in tertiary institutions between 2012 and 2016. The immensely wide gender gap in BTVET education that existed up to 2006 (averaging 75% for male and 25% for female) was narrowed down to 56% for boys and 44% for girls thereafter. Women enrolment at university level increased from 23% in 1989 to 35% between 1999 and 2001; 41% in 2002 and 57% in 2005; thereafter decreasing to 31% in 2011 before rising again to an average of 44% between 2012 and 2016. The science preference policy has been partially blamed for shattering girls' hopes for higher education. Before the policy, about 37% of government merit scholarships to university were awarded to women. Admission lists of government sponsored students to public institutions of higher learning showed declines in female students admitted on merit – 29% in 2007 rising to 42% in 2008 and steadily declining to 28% by 2012 before picking up again to 44% in 2017. Recent global gender gap reports reveal that males dominate in agricultural, engineering and natural sciences while there is gender parity in the medical/ health sciences and a narrower gap in information, communication and technology. Females continued to dominate in all non-science fields of study, more so in the services sector. The 2015 UNESCO Science Report indicated very low representation of females in all science fields with 17.1% in natural sciences, 23.3% in engineering and technology, 30.6% in medical sciences, 19.7% in agricultural sciences, and 27% in social sciences. Another 2016 assessment of gender and Science, Technology and Innovation (ST&I) in Uganda reported an overall ratio of 39% female participation, with a considerable variation between institutions. Various reports on ST&I indicators showed female researchers constituted 24.3% of a total head count and 26.3% of full-time equivalent (FTE) in 2012 and 29.8% of FTE in 2014 down from 40% in 2008/09. Female agricultural researchers rose from 20% in 2008 to 30% in 2016. Only nine (13.9%) of the 65 Fellows listed on

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the Uganda National Academy of Sciences website are female. The global gender parity reports published by the World Economic Forum indicated women representation in the professional and technical workspace in Uganda to have increased from 22% in 2006 to 34 - 36% since 2014. A recent analysis of patent statistics between 1998 and 2017 by the Intellectual Property Office of the United Kingdom ranked Uganda with the second highest proportion of female inventors worldwide at female involvement of 45% behind Togo's 57%. National statistics indicated males dominated business ownership in almost all the industry sectors (61% in 2002 and 56% in 2007), while females dominated the sector of accommodation and food Services as well as education, health and social work. The information generated in this study provide baseline information for poicy intervention in Uganda and elsewhere.

Keywords: Gender, Science education, ST&I, Uganda

RÉSUMÉ

La politique Ougandaise pour l'Education Scientifique de 2005 a rendu l'étude de la physique et de la chimie obligatoire pour les élèves du premier cycle du niveau secondaire, en plus de la biologie, de l'anglais et des mathématiques. Pendant que les garçons et les filles sont équitablement représentés dans les matières des sciences dès le plus jeune âge, la représentation des femmes dans les disciplines scientifiques diminue avec l'augmentation des niveaux d'éducation et de responsabilité professionnelle. Les inscriptions en sciences au niveau secondaire supérieur ne représentent qu'environ 20% du total des inscriptions. Seulement 16% et 14%, respectivement des garçons et filles ayant terminé le cursus primaire ont pu fréquenter le secondaire. En 2000, les filles représentaient 44% des inscriptions au premier cycle du niveau secondaire, 25% pour le second cycle et 35% dans les établissements tertiaires. La proportion de filles a augmenté régulièrement pour atteindre 46%, 41% et 44% respectivement au premier cycle, au second cycle et dans les établissements d'enseignement supérieur entre 2012 et 2016. L'écart extrêmement important entre les sexes dans l'enseignement technique et professionnel qui existait jusqu'en 2006 (en moyenne 75% pour les hommes et 25% pour les femmes) a été réduit à 56% et 44% par la suite. Le taux d'inscription des femmes au niveau universitaire est passé de 23% en 1989 à 35% entre 1999 et 2001; 41% en 2002 et 57% en 2005; diminuant ensuite à 31% en 2011 avant de remonter à une moyenne de 44% entre 2012 et 2016. Avant la politique, environ 37% des bourses de mérite du gouvernement à l'université étaient accordées à des femmes. Les listes d'admission d'étudiants sponsorisés par le gouvernement dans les établissements publics d'enseignement supérieur ont montré une baisse du nombre d'étudiantes admises par mérite - 29% en 2007, passant à 42% en 2008 et diminuant régulièrement à 28% en 2012 avant de remonter à 44% en 2017. Les rapports mondiaux sur les écarts entre les sexes révèlent que les hommes dominent dans les domaines de l'agriculture, de l'ingénierie et des sciences naturelles, tandis qu'il existe une parité dans les sciences médicales et de santé et un écart plus étroit dans l'information, la communication et la technologie. Les femmes ont continué de dominer dans tous les domaines d'études non scientifiques, plus encore dans le secteur des services. Le rapport de l'UNESCO sur la science 2015 indiquait une très faible représentation des femmes dans tous les domaines scientifiques avec 17,1% en sciences naturelles, 23,3% en ingénierie et technologie, 30,6% en sciences médicales, 19,7% en sciences agricoles et 27% en sciences sociales. Une autre évaluation de 2016 sur le genre et la science, la technologie et l'innovation (ST&I) en Ouganda a rapporté un ratio global de 39% de participation féminine, avec une variation considérable entre les institutions. Divers rapports sur les indicateurs ST&I ont montré que les femmes chercheurs représentaient 24,3% du nombre total de personnes et 26,3% de l'équivalent temps plein (ETP) en 2012 et 29,8% des ETP en 2014, contre 40% en 2008/09. Les femmes agronomes sont passées de 20% en 2008 à 30% en 2016. Seuls neuf (13,9%) des 65 boursiers répertoriés sur le site Web de l'Académie nationale des sciences de l'Ouganda sont des femmes. Les rapports mondiaux sur la parité entre les sexes publiés par le Forum économique mondial indiquent que la représentation des femmes dans l'espace de travail professionnel et technique en Ouganda est passée de 22% en 2006 à 34 - 36% depuis 2014. Une analyse récente des statistiques sur les brevets entre 1998 et 2017 classe l'Ouganda avec la deuxième proportion la plus élevée de femmes inventrices dans le monde, avec une participation féminine de 45%, contre 57% au Togo. Les statistiques nationales indiquent que les hommes dominent la propriété des entreprises dans presque tous les secteurs industriels (61% en 2002 et 56% en 2007), tandis que les femmes dominent le secteur de l'hébergement et des services de restauration ainsi que l'éducation, la santé et le travail social. Les informations générées dans cette étude fournissent des informations de base pour une intervention politique en Ouganda et ailleurs.

Mots-clés: Genre, Enseignement des sciences, ST&I, Ouganda

INTRODUCTION

The National Science Technology and Innovation (ST&I) system is made up of different actors (research institutes, universities, technology transfer agencies, chambers of commerce and industry, financing institutions, investors, government departments, individual firms as well as company networks and industry clusters of producers, product aggregators, voluntary professional associations, and regulatory agencies) and their interactions. The aim of a national ST&I system is to produce knowledge and information, and ensure its spread and diffusion in order to be used for economic development. The system supports the various actors in their innovation (knowledge and technology generation) and business development needs for competitiveness and rapid technological change.

The strength of a national ST&I system relies on:

- Infrastructure - the facilities, organisations, agencies, institutions, regulatory frameworks (including rules, norms and standards), resources (including human, financial, material) and related services used by the scientific community;
- Structural capital - the sectoral and disciplinary composition comprised of organisational culture, intellectual property and processes; and,
- Relational capital - the interactions across and within components of the ST&I system characterised by formal and informal relationships, networks, partnerships, alliances, reputation, brand image, stakeholder engagement, licensing agreements and joint ventures.

Individual passage through the science, technology and innovation (ST&I) ecosystem is characteristically an eight step process from basic education through professional formation and practice to inactive retirement. There are requirements to succeed along this protracted development pathway from school to operating independently as a professional, each with numerous bottlenecks, especially for girls and women. Few differences exist between girls' and boys' attitudes towards science in the early school years and their aspirations to pursue science, technology, engineering and mathematics (STEM) study and careers. The level of participation and achievement by girls and women is conditioned by the health, social, cultural and education conditions and the policies that support or hinder their participation, influencing both the courses they choose to take in those areas and the level of effort they put forth in these courses. The decreasing representation of women in ST&I from secondary school to university, professional practice and technical innovation, and then management, known as the “leaky pipeline” is largely due to gender biases in the teaching and study of STEM subjects, gender-blind institutional practices, domestic and career responsibilities, inflexible working hours, and limited support for women in entrepreneurial development. Women being powerful agents of change, it is critical that their interests and concerns are reflected in efforts at harnessing ST&I for development by applying a gender lens. This was the rationale for this study which examined evaluation and current status of the ST&I ecosystem so as to guide future planning . The study involved desk review of documents and interaction with institution and other individual actors enagaged in ST&I activities in Uganda.

The Uganda ST&I ecosystem: Country study findings

Education sub-system. Basic education in Uganda, which is free through the Universal Primary Education (UPE) policy of 1996, consists of pre-primary education, primary education and lower secondary education during which the study of STEM subjects is mandatory. The entry age to primary education is six years old. Primary education lasts for seven years from P1 to P7. Secondary education, which lasts for six years from S1 to S6, gradually became free through the implementation of the Universal Secondary Education (USE) initiative and Universal Post Primary Education and Training (UPPET) programmes since 2007. The Uganda Science Education Policy of 2005 made the study of Physics and Chemistry compulsory for O-Level secondary school students in addition to Biology, English and Mathematics. The vocational education system is three-tiered so one can join a vocational training institution on completion of primary school, after O-level and at tertiary level. The duration of tertiary education ranges from two to five years depending on the course enrolled for. The higher education sub-sector had 152 institutions in 2005. The university level had 9 public and 41 private universities, while other tertiary institutions were 112 public and 49 private by 2016.

Public universities are mainly science and technology-oriented. Teaching is the main focus of most universities, although research capacity is growing. The spatial location of public universities in the various regions of the country, and an emphasis on STEM education, is likely in the long term to have a positive influence on the local innovative activities of surrounding firms and communities. At the same time, entrepreneurial activities are gaining prominence within university systems. These show an increasing recognition of the value of university-industry-government links.

Most students prefer university programmes, as are their parents and policy makers. The result is lack of middle level technicians and workers. For example, in 2011 only 1.05% programmes in Health Sciences and 0.86% in engineering were for diploma level. A total of 2,099 programmes were offered; of which 1,105 were in universities, 664 in teacher training and 114 in management. The academic staff numbers and infrastructure growth have not kept pace with student enrolment growth. For example, while students numbers grew by 14.2% in 2010/11, staff numbers grew by only 10.6%. In 2010, there were 7,871 academics and by 2011, the number was 8,702. Only 11% of academic staff had PhDs although the number increased in absolute terms from 858 in 2010 to 914 in 2011. Masters increased from 2,967 (38%) to 3,657 (42%) while Bachelors represented 34%. The overall academic staff/student ratio was 23. The ratios for specific categories of institutions were far below the standards set by the National Council for Higher Education.

Research sub-system. The Uganda research system is liberalised although it is still largely undertaken by public research institutes and universities. There are a few private enterprises and international research organisations. The institutions conduct basic research; carry out research to improve organizational, program or project performance; and, engage in applied research and commercial product development. The research institutions may be categorised into:

a) Institutions mandated to formulate and implement research policy and national level coordination;
b) Regulatory institutions including those for standards and intellectual property management;
c) Research institutions which carry out research;
d) Training institutions which produce the human resources for research, as well as carrying out research especially as a component of graduate training programs; and,
e) Research support institutions which plan and manage research activities as well as the financing and dissemination of research results.

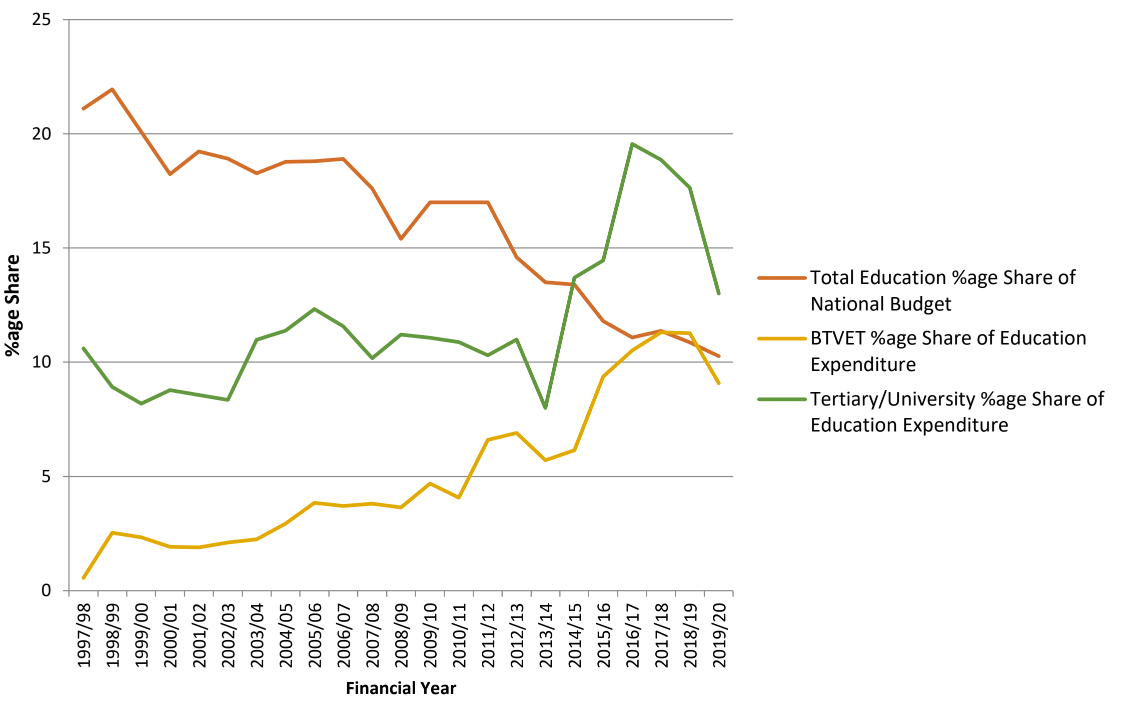
Professional practice, entrepreneurship and paid employment. About 400,000 youths are released into the job market after graduating every year, yet the job market is only able to provide employment to about 90,000 resulting in a youth unemployment rate of 22.5%. Ugandan universities alone graduate over 40,000 youth every year, yet the market can provide only 8,000 jobs annually. According to results from the 2009/10 Uganda National Household Survey (UNHS), 75.9% of Ugandans were self-employed, including 86.2% of working women and 72.1% of working men. A large share of the active labour force is engaged in entrepreneurship mainly in the service sector. The self-employment rate was high among youth of 18-30 years of age: 61.5% among young women and 52.5% among young men. The average labour force participation rate was very high – 92.2% for men and 91% for women, indicating a paucity of paid employment opportunities. Only 13.8% of working women were in paid employment, compared to 27.9% of working men. Given this dynamic, it is likely that more women would move from self-employment into paid jobs if these were available to them. Uganda's labour force grew at a compound rate of 3.8% between 2007 and 2017 resulting in 606,000 new jobseekers; yet only 147,000 formal jobs were created in 2016 (ANDE, 2018). Unemployed graduates are an exasperated group of young people. A large percentage of these youth have had very frustrating experiences trying to enter the workplace, and often do not get meaningful work even when appointed.

Merit (qualifications and experience) is still a cardinal principle in recruitment. For example, between 2015 and 2016 the New Vision newspaper advertised 8,358 jobs - 41% required possession of an undergraduate degree, 19% Masters/postgraduate, 17% Diploma, 12% Certificate and 1% a PhD degree; 51% wanted candidates with work or job oriented skills, 15% demanded experience in a specific field, and 26% wanted those who had additional professional qualifications. However, the requirement for experience is fast waning especially with jobs based on new technology. The smaller pool from which to select, and the generally observed lower performance of women, inevitably disadvantages them especially when such gender-blind policies are followed to the rule.

There is a growing demand for talent in the IT job sector: from established entities, whether public or private, who need a steady flow of IT specialists in a range of roles; a thriving start-ups community, a large proportion of which is based on new technology; and international freelancing work. A recent study (Mercy Corps, 2019) indicated that 48% of all IT-related job postings were for mid-level IT administration roles in networking, hardware and software maintenance, from diverse industries ranging from government, NGOs, finance, entertainment, energy, airlines, and the education sector. Data-related job postings, largely from the NGO and research sector, accounted for 21%, mainly for data and business intelligence roles including data managers, officers, administrators and analysts – rarely for data scientists; 13% were for developers for government, health, logistics, and finance industry. Only 28% of the job postings were looking for senior-level applicants.

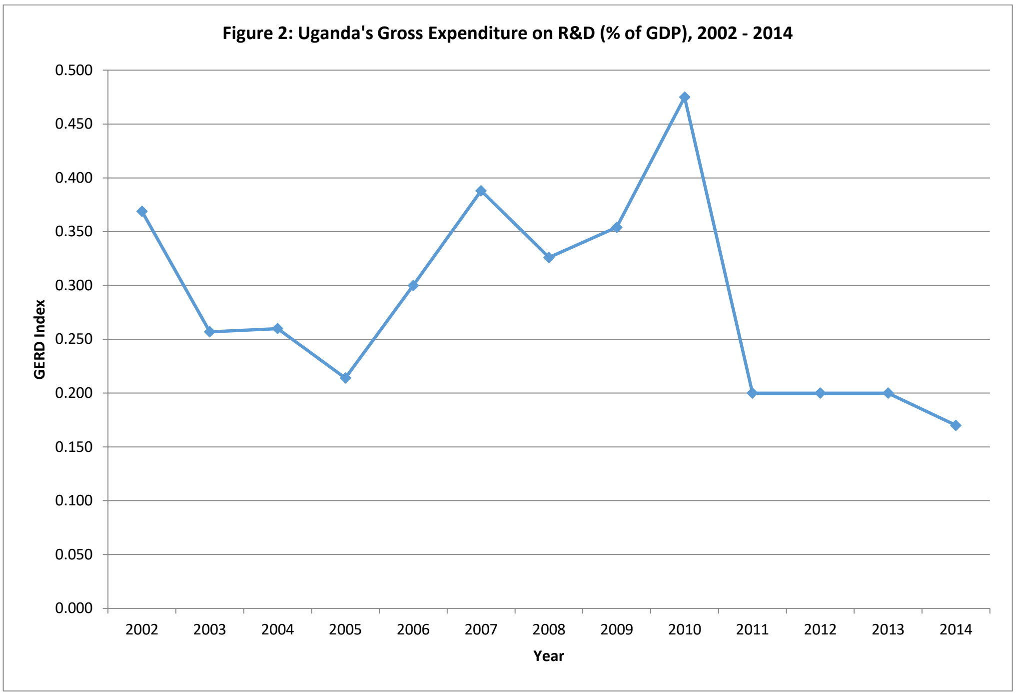
Investment in science education and research. Uganda's long-term Vision 2040 and the second National Development Plan (NDP II), while emphasising transformation and industrialisation, stress the importance of 'inclusive growth' to create sustainable development. The key poverty alleviating sectors targeted for domestic public spending include health, education, water, environment and agriculture. These sectors together took up 26.5% of the country's 2017/18 approved budget allocations: agriculture (3.8%), health (8.4%), education (11.4%) and water (2.9%). This level of public spending is not being sufficiently redistributive in nature nor leading to inclusive growth, because the country's revenue expenditure is not sufficiently targeting the poorest. For the past 5+ years Uganda's budget and resource allocation has been skewed towards infrastructure spending in the works, transport and energy sectors, compromising the efforts for inclusiveness.

Figure 1. Uganda Budget share for education sector, 1997-2019



A synthesis of information in the Medium Term Expenditure Frameworks (MTEFs), the Ministry of Education and Sports (MoES) Annual Budget Performance Reports (ABPR) and other resources (Nakanyike-Musisi and Nakayiwa-Mayega, 2010) revealed that although absolute amounts allocated have been increasing, the share of education expenditure in the national budget and GDP has been sharply declining since the late 1990's (Figure 1). Education sector expenditures grew from 11.5% in 1991 (1.5% of GDP) to 21% of national budget between 1997 and 2000. Thereafter, the share steadily declined to 18% between 2001 and 2006 (about 5.2% of GDP) to the current 10%. Budgetary allocations to the BTVET sector have steadily increased from a low 0.6% in 1997 to 4.7% in 2009 and 11% in 2017 before dipping back to 9.1% in 2019. Investment in tertiary/university education declined from 10.6% in 1997 to 8.4% in 2002 and averaged about 11% of public education expenditure between 2003 and 2012 when it shot up reaching 19.6% in 2016 and then sharply declined to 13% in 2019.

UNESCO and the Uganda National Council for Science and Technology (UNCST) statistics indicate that Uganda's GERD (gross expenditure on research and development as a % of GDP) averaged 0.31 percent between 2002 and 2014, with a minimum of 0.17 percent in 2014 and a maximum of 0.48 percent in 2010 (Figure 2) when Uganda was ranked 68th in the world, spending about US$ 0.28 billion on R&D. The R&D intensity (GERD/GDP) was 0.6 per cent in 2009 which was still below the Africa continentally agreed target of investing 1% of national GDP to science and technology. Most of the research expenditure came from external donors and government largely funded programmes in public research and higher education institutions. The UNCST 2011 ST&I Status Report indicated government expenditures on science and technology of UGX 359.8 billion in 2007, UGX 367 billion in 2008 and UGX 479 billion in 2009 or a GERD of 1.1% in 2007, 1.9% in 2008 and 2.3% in 2009. More broadly, Government R&D expenditure increased from UGX 61.1 billion in 2008 (0.31%) to UGX 79.7 billion (0.39%) in 2009. The 2012 Global Innovation Index put Uganda at position 117 with a score of 25.6. Uganda's



capacity to innovate was this low because the precipitants of innovation (e.g. stock of scientists, engineers, and S&T institutions) were far below international average due to inadequate research infrastructure, low quality of research institutions and the high levels of brain drain.

Enabling policy environment for women participation. The promulgation and institution of "quota" laws and policies since 1986 contributed to a leap in female participation in political institutions, increased girl child enrolment in school, and the gradual transformation of the legislative agenda. Diverse academic, research, and women's organizations have taken actions to promote the design and implementation of public policies geared toward resolving gender inequalities in various fields. A significant number of laws have been enacted, and policies and programs implemented that sought directly or indirectly to improve women's (social, educational, and health) conditions, economic autonomy, civic participation, and empowerment. A recent study (Ssali, 2019) documenting existing gender equality local and international laws and policies and analysis of the state of their implementation, and an earlier assessment of gender equality and ST&I (WISAT/ WOUGNET, 2015) conclude that while Uganda had strong gender-sensitive policies and legislative measures, problems remained in implementing existing laws and policies.

There is evidence of progress in women's representation in decision-making, but the benefits of these policies are yet to be seen in other socio-economic indicators. Nonetheless, most of the existing gender policies and laws, although issue specific, collectively compel all government ministries, departments and agencies (MDA's) to have policies, strategies and programmes for addressing gender and equality issues. The UNDP Gender Inequality Index (GII) as reported in the Human Development Reports indicate that Uganda reduced its gender equality gap from 70% in 1996 to 59% in 2001 and 48% in 2017. Rankings by the WEF global gender gap index indicate that overall and for economic participation and opportunity, Uganda has on average narrowed its gender gap by about 70% and yet to cover the remaining 30%. Performance has even been more pronounced in education attainment (over 90%) and in health and survival (98%). Parity in political empowerment averaged 30%, close to the constitutional affirmative action requirement of one-third representation. Statistics from Ministry of Gender, Labour and Social Development (MoGLSD) and the Parliament of Uganda indicate that through constitutionally guaranteed affirmative action measures, women in parliament increased from 3% in the 4th parliament (1980–1985) to 43% in the 9th Parliament (2011–2016) before dropping to 35% in the current 10th parliament. In 1989 there were two women serving as ministers and three serving as deputy ministers in cabinet. The number of women in cabinet was at 23% in 2015 and 39% in 2019 comprising 18 women (50%) and 18 men as Ministers and 32 men and 14 (30%) women as Ministers of State. Women Local Council leaders, increased from 6% in the early 1990s to 44% in 2003.

A study examining gender equality in public administration in Uganda focusing on equal par-ticipation of women as staff, including at decision-making levels (UNDP, 2012) indicated that in 2011, women constituted only 33% of all staff in the public service, with the majority at the lowest levels. Women made up only 22% of senior management Public Service positions and 16% of middle management posi tions. Ministry of Local Government (MoLG) data for 2011 and 2012 also showed that women constituted only 8% of the Chief Administrative Officers (CAOs) and 13 percent of the Deputy CAOs, a proportion that was far below the national average in the entire Public Service. At municipality town clerk level, the percentage of women decreased from 34% to 9%, thereby lowering overall proportion of women in local government positions from 15% in 2011 to 9% in 2012. The top positions in local governments, as in central government and in education, were dominated by men. Uganda's Public, Health and Education Services have both occupational segregation, where particular sectors or types of work such as nursing, secretarial and clerical jobs, and pre-primary and primary education are female-dominated, as well as hierarchical segregation, where men dominate the top positions and women the lower ones. As such, Uganda's public administration is structured along gender lines, where men dominate certain jobs and sectors and women are concentrated in sectors that require lesser skills and are care-related.

Science for Women: ST&I approaches with a gender lens. Women's and men's contributions to economic and development activity vary. They have varying access to resources, development of capabilities and opportunities, and different socially constructed roles and accepted responsibilities. Women's activities in food production, community management, natural resources management, education of children and family care place them at the centre of development. ST&I can play several roles in supporting women's development and livelihood activities. Technology may not be the answer to closing gender inequality, but it is a powerful enabler. The national ST&I system needs prudent ways to enable the private sector, technology industry, and governments work together to innovate smartly and responsibly.

In the agriculture sector, since the adoption of a new agricultural research policy in the early 2000s, most institutions in the national agricultural research system (NARS), especially the institutes of the National Agricultural Research Organisation (NARO) and the universities, adopted research processes and approaches which benefit women. These processes involve consulting and working with women in the choice, development and application of technology. The adoption of participatory and community engagement approaches provided insights into access, opportunities, priorities and choices among women and men in a range of social groupings. Applying a gender lens by integrating gender concerns and taking steps to understand gender patterns of use and access have been critical for promoting ST&I for women in agriculture.

A number of gender-biased/focused ST&I initiatives for validating, protecting and improving local knowledge, innovations and skills around food production, energy, water, nutrition, transport and natural resource management exist and various technologies have been developed and disseminated - particularly those focused on easing the workload and improving the health of women, dealing with gender differentiated needs and problems, or presenting unique opportunities to women. In Healthcare and environment, technologies that enable improved access to sanitation, waste management, and clean and potable water; and the development and deployment of modern, clean, affordable and sustainable (green and renewable) energy (domestic biogas, solar home systems) and clean and efficient household cooking solutions and home designs (cook stoves that use a wider variety of biomass for fuel, chimneys/hoods and adequate ventilation in kitchens) has contributed to improved health, time savings through the reduced drudgery associated with fuel collection, and environmental benefits. ICTs and modern technologies have also been variously employed to provide a convenient avenue for both women and men to access information and knowledge that helps build sustainable livelihoods, improve health and well-being – in the areas of agriculture, entrepreneurship, financial services, social services, education, and mentoring and networking.

Women's participation in ST&I has gradually become a priority national issue and actions to encourage girls to continue the study of STEM throughout their schooling and into university and working life initiated. The range of support activities include: gender-biased policies and support frameworks; enhancing knowledge and understanding of STEM concepts by girls; forming networks with like-minded peers; meeting and networking with women in STEM careers; providing career information, including opportunities for internships and scholarships to support female university students to continue their studies and pursue ST&I career pathways; mentorship, technical support and policy advocacy services; challenges and training programmes; conferences, mentoring opportunities, and programs that encourage female professionals to remain in the ST&I fields, etc. A good number of networks and agencies provide advocacy and support for girls and women in STEM study and ST&I professional practice. These institutions and networks immensely contributed to uplifting the quality of life of women, in the professional, formal and informal sectors.

Women in science: Gender equality trends in basic science and mathematics education. Literacy discrepancies and educational inequity are a serious factor in the propagation of gender inequality. The foundation for interest in STEM subjects is laid early in the education pipeline. Although female school attendance at all levels of society in Uganda is lower than that of their male counterparts, equitable access to education has considerably increased, in a context of strong population growth of 3.3% per year. The introduction of UPE in 1997 led to a significant increase in the enrolment figures in the primary sub-sector, especially for girls. The total pupil enrolment increased from 2.7 million pupils in 1995 to 5.3 million in 1997. Between 2000 and 2016, enrolment at primary level rose from 6.6 million to 8.7 million pupils (ODI, 2010; JICA, 2012; MoES, 2017). The proportion of school age children (6-12 years) enrolling in primary school rose from 79% in 2000 to 83% in 2003 before plummeting to 68% in 2011. This shot up again in 2012 to over 90% but has been declining since then. By the year 2000, the gender gap in primary education had been closed and gender parity achieved. The gender parity index in primary education between 2000 and 2008 was actually greater than one, implying more girls enrolled than boys. Between 1997 when UPE started and 2015, there was a 169% increase in enrolment with boys registering a 150% increase and girls a 192% phenomenal increase.

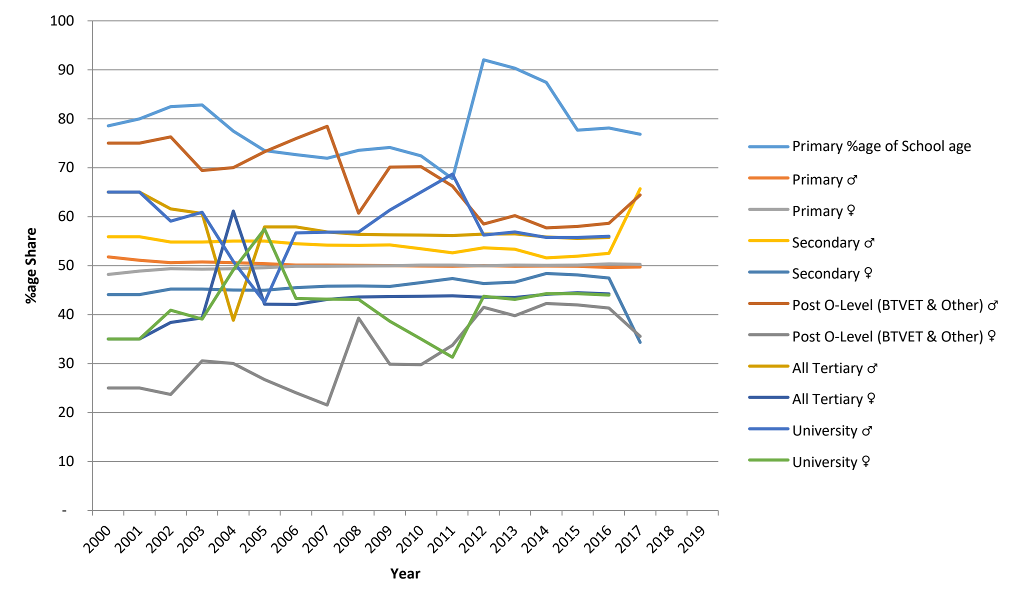
Massive leakages occur along the education pipeline, especially for girls (MoES, 2017). Education census data from 2004, for example, indicated that for every ten students enrolled in primary schools, only one was enrolled at a secondary institution. Although survival (the number of pupils that make it to the top class at each level in proportion to those that joined at the entry level in each cohort of admissions) and transition (the number of students that join the next level in the education pipeline in proportion to the candidates that sat the qualifying exams the previous year) rates for both boys and girls in primary school were reported to be almost the same, the rates decreased between 2011 and 2015. Survival rates declined from 32% (boys) and 31% (girls) to 30% for both boys and girls in 2015 while transition rates declined from 67% (boys) and 64% (girls) in 2011 to 53% (boys) and 52% (girls) in 2015. Between 2000 and 2016, a total of 66.8 million boys and 66.1 million girls attended primary school, giving an average of 9.5 million for both boys and girls in each of the 7 years of primary school education. Only 16% of the boys and 14% of the girls completing primary school got to attend secondary school. The gender gap has continued to narrow. Girls constituted only 44%

of enrolments at secondary level, 25% in post O-level institutions and 35% in tertiary level institutions in 2000. The proportion of girls steadily increased to 46% in secondary, 41% in post O-level and 44% in tertiary institutions between 2012 and 2016 (Figure 3).

Women in science: gender equality trends in tertiary education. In 1991, the Government of Uganda instituted a policy where girls entering university were given an extra 1.5 points to address the persistent gap in enrolment of women in higher institutions. This measure resulted in a surge in women's enrolment so that, in some university courses, women were in the majority. The higher education sub-sector has continued to expand in terms of student enrolments and the number of institutions. These increases, however, have occurred in the face of declining or stagnant unit cost funding for education facilities, infrastructure and academic staff. Although 60,000 to 70,000 students leave secondary school each year qualified to go on to higher education, only some 42% of the boys and 35% of the girls are able to find places at the limited number of institutions. The majority of students go to universities, both public and private.

Women enrolment at university level increased from 23% in 1989 to 35% between 1999 and 2001; 41% in 2002 and 57% in 2005; thereafter decreasing to 31% in 2011 before rising again to an average of 44% between 2012 and 2016. A revision of the 1.5 points policy has a provision to the effect that any disadvantaged gender should have a minimum enrolment. The NCHE statistics (NCHE, 2013) indicate that total enrolments in the tertiary sector continued to grow since the 1980's. Most of this growth continued to be in Universities and affiliated colleges in the 1990's and 2000's. University level enrolment grew from 57,144 students in 2002 to 186,412 in 2016. Gross enrolment ratio, the students enrolled in higher education institutions, regardless of age, as a percentage of the population of the relevant age range expected to be in higher education institutions, grew from 5.4% in 2010 to 6.2% in 2011. This growth was still inadequate compared to the world average of 17.4%.

Figure 3: Gender parity by level of education, 2000 - 2019



The immensely wide gender gap in BTVET education that existed up to 2006 (averaging 75% for male and 25% for female) was narrowed down to 56% for boys and 44% for girls thereafter. Student enrolment in BTVET institutions steadily increased from a very low 14,000 students in 2000 to 47,298 in 2008 and 63,285 in 2017. The Uganda Business, Technical and Vocational Education and Training (BTVET) Strategic Plan 2011 –2020 gives female BTVET graduates preferential access to BTVET Instructors training and targets 35% of female enrolment in industrial training programmes.

Women in science: gender equality trends in STEM study disciplines. Affirmative action exists for STEM education, and is important for two reasons. First, the measures help over the long term to ensure a cohort of qualified women for STI and other fields (and having good employ ment prospects could similarly stimulate enrolment in STEM study). Second, such a measure could be considered in the Public Service, although it would need to be backed up by extra measures, such as reforming the recruitment process and fast-tracking women in promotions and training, in order to attract and equip talented women as well as sensitizing employers to benefits of employing women.

The Uganda Science Education Policy (2005) made the study of Physics and Chemistry compulsory for O-Level secondary school students in addition to Biology, English and Mathematics. Enrolments in sciences at the upper secondary school level are only about 20% of the total enrolments. The science preference policy also required first year students at university to take some science subjects. Government also decreed that science students would receive 75% of the Government scholarships to public universities and tertiary institutions. Increased female enrolment in STEM is one of the objectives of the Higher Education Students' Loan Scheme introduced in 2013.

The NCHE introduced a bridging and conversion programme in July 2019 as part of university education to enable students who did not offer STEM subjects at A-Level take science courses and obtain certification after 1 year of study. Busitema University has a 27–30% quota for female students at each intake. Makerere University Council in August 2019 approved an affirmative action policy ring-fencing 40% of vacancies in all STEM disciplines for women; and runs various female scholarship initiatives for students from disadvantaged socio-economic backgrounds admitted specifically to science-based programmes. Mbarara University of Science and Technology (MUST), with support from Google runs a "STEM for Girls" project that organises workshops to build the capacity of secondary school science and mathematics teachers in order to put them in a better position to prepare and encourage girls' involvement in STEM; and also visits schools to talk to girls about the available STEM career paths, show them profiles of females working in STEM, encourage them to believe that they can make it in STEM, and connect them to mentors. It also organises STEM Camps where female mentors help girls see themselves in STEM roles they had never imagined before. The African Rural University is a women only university for rural transformation that focuses on teaching sustainable agriculture exclusively to women.

MoES and NCHE reports indicate that there were significant improvements in female access to higher education, computer access and use, as well as enrolment in science and technology. However, the S&T enrolments were largely in computer-related areas rather than in basic, mathematical or other technical sciences. Overall university enrolment increased on average by 14% between 2000 and 2006, while the average annual growth rate for STEM enrolments was higher at 22%. Despite this rate of growth, total student enrolment in science and technology at both private and public universities continued to lag, reported at less than 27% in 2006. The NCHE further reports that enrolment into Science and Technology disciplines (physical, natural, health, mathematical, engineering, computer, agricultural, architectural, forestry, and fisheries sciences) declined to 26% in 2011 from 35% in 2010. The minimum recommended registration in science and technology in order for a country to economically take off and participate in the global knowledge based economy is 40% (UBOS, 2017). At the non-university level, only 6% out of 198,061 students were enrolled in science and technology – mainly for computer science and related courses.

Evidence reveals that the compulsory sciences aspect of the education policy resulted in increased student enrolment in STEM studies. The science preference policy, however, has been blamed for partially shattering girls' hopes for higher education, as noted from the widened gender gap in enrolments between 2007 and 2012. Before the policy, about 37% of government merit scholarships to university were awarded to women. The admission lists of government sponsored students to public institutions of higher learning showed further declines in female students admitted on merit – 29% in 2007 rising to 42% in 2008 and steadily declining again to 28% in 2012 (Namatende-Sakwa and Chia, 2013). The gender parity gap has since been narrowed, with males constituting 56% and females 44% in 2017.

Despite the number of female students pursuing sciences at tertiary level increasing, it did not match the increments in the non-science disciplines. The 2017 and 2018 global gender gap reports revealed major differences in gender equality in major fields of STEM studies. Males dominated in agricultural, engineering and natural sciences (the hard and/or highly menial/practical sciences) while there was gender parity in the medical/health sciences and a narrower gap in ICT. Females continued to dominate in all non-science fields of study, more so in the services sector (Figure 4). NCHE also reported that whereas female enrolments in the humanities rose by 109% during 2008-2010, this was only 18% in the medical sciences for the same period. Enrolment for female students in higher education institutions in 2005 stood at 41% rising to 44% by 2010. The only category of institutions where there were more females than males were Meteorology (62%), Management & Social Development (57%), Hotel and Tourism (54%) and Commerce/Business (51%). Males continued to dominate Survey and Land Management (90%), Aviation (86%), Theological Colleges (83%) and Agricultural Colleges (72%). The 2015 UNESCO Science Report indicated very low representation of females in all science fields with 17.1% in natural sciences, 23.3% in engineering and technology, 30.6% in medical sciences, 19.7% in agricultural sciences, and 27% in social sciences. The WISAT 2016 assessment of gender and STI in Uganda reported an overall ratio of 39% female participation, with a considerable variation between institutions.

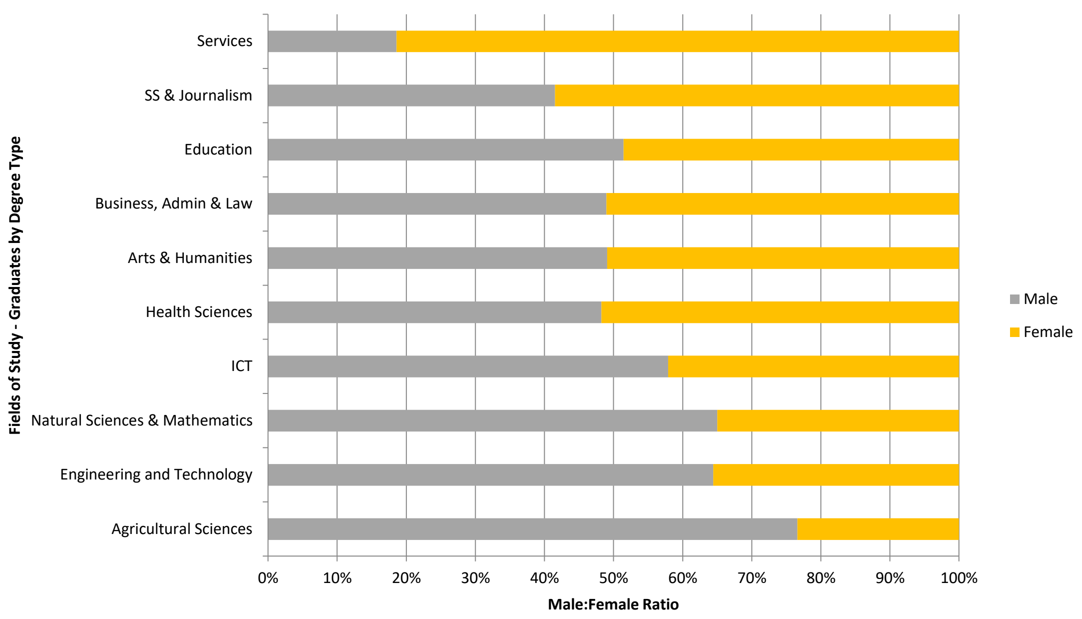
Women in the STI workforce and professional practice. The impact of affirmative action in education policy has visibly narrowed gender gaps in education, but this has not yet translated into women's equal participation in employment. Various factors are suggested, including women's lack of self-esteem, societal factors and underlying gender stereotypes that limit women's potential in the job market. Affirmative action policy that has been implemented in politics and education sectors has not been extended into the broader employment sector so that after graduation, women have to face the competitive world of work where male privilege is still largely the norm. Even in fields where there are qualified women and their numbers have been rising, such as social work and law, this is not yet reflected in women's participation, especially in the Public Service.

Besides, even if official statistics can be difficult to access, a cursory observation shows that, even in feminized sectors such as education, the pyramid that places women at the bottom of the ladder persists. Therefore, although affirmative action boosts the number of women to attain education, the only place where their seats are guaranteed is in politics. In the world of work, they have to compete on an equal basis with men and compete for the available jobs where, as evidenced from the structure of the public service and many organisations, women still dominate stereotyped jobs of personal assistants, receptionists or tea persons.

Technology was for long indisputably considered a man's arena and a simple statistics show men are likely to gain 1 job for every 3 lost to technology. Majority of the women in the STEM courses were more likely to drop it for a rather deemed "feminine" degrees for myriads of reasons from community influence to cultural believe that made science a boy's club. However, as Ugandan society became more gender equal year on year, women started to stand up and be counted. More than ever before, girls are studying and excelling in STEM disciplines. And the women thriving in STEM industry are continually mentoring, inspiring and motivating young girls willing to take the careers, which is a good start. However, the representation of women working as professionals in the STI ecosystem has not matched the dramatic increase in girls' educational achievements in these subjects. Women face considerable barriers as they move up the education ladder to research and professional careers. The share of women science career professionals and researchers differs from one field to another.

The Uganda Bureau of Statistics (UBOS) indicated that of the 1.1 million persons who were employed as business owners in 2007, about 56% (as compared to 61% in 2002) were male, who also dominated almost all the industry sectors. Females dominated the

Figure 4: Gender parity in science and other fields of study at tertiary level, 2017 - 2018



sector of accommodation and food Services as well as education, health and social work. The UNESCO (2015), NEPAD (2014) and UNCST statistics indicate that the number of researchers in Uganda doubled from 1,768 in 2007 and 1,387 in 2008 to 2,823 in 2010 and 1,942 in 2014.

Female researchers constituted 24.3% of a total head count and 26.3% of full-time equivalent (FTE) in 2012 and 29.8% of FTE in 2014 down from 40% in 2008/09 (UNCST, 2013). The total number of agricultural researchers was reported to be 559 FTE in 2016 (ASTI/IFPRI, 2018) with the share of female agricultural researchers rising from 20% in 2008 to 30% in 2016. The Uganda National Academy of Sciences lists 65 Fellows on their website. Only nine of these (13.9%) are female. As reported in the WEF global gender parity reports, women representation in the professional and technical workspace in Uganda increased from 22% in 2006 to between 34 and 36% since 2014.

Among seven RUFORUM member universities (ASTI/RUFORUM, 2018), which accounted for a combined 83% of the teaching staff employed at Uganda's 15 agriculture-related higher education agencies, teaching capacity ranged from 15 to more than 150 staff, with varying ratios (10 – 47%) of female teaching staff. In general, female researchers and academics were younger and less qualified compared with their male counterparts. About 30% of the students enrolled in agriculture-related programs were female, but shares differed by institution and degree. In general, the share of female graduating students was lower than the share in female students enrolled.

A study (UNCST, 2016) to trace and establish the career trajectory of a cohort of engineers who graduated between 2008 and 2012 indicated that whereas 72% of engineering graduates described their current occupation as being 'closely related' to their undergraduate training, 34% of female engineers were in professions that were not related to engineering. In addition, whereas the number of male engineers in 'unrelated' professions reduced by 11%, the number of female engineers in such professions increased by 400% between 2008 and 2012. The increase in number of engineers in 'closely-related' professions was 46% for female and 123% for male graduates, respectively. Proportionately, far fewer women engineers were registered, and only 14.8% of female engineers were nationally mobile.

Women in the innovation system: entrepreneurship and job creation. A recent analysis of patent statistics by the Intellectual Property Office of the United Kingdom (IPO, 2019) found that an increasing proportion of patent inventors worldwide are female. Between 1998 and 2017, the proportion of female inventors worldwide almost doubled from 6.8% to 12.7%. Further, the proportion of patent applications that named a female amongst their inventors rose from 12% to 21% over the same period, and the proportion of applications with at least as many female inventors as males rose from 3% to 8%. Some countries boasted a far higher female share, particularly in Africa. The study found that Uganda had the second highest proportion of female involvement at 44.55 percent behind Togo's 57.14 percent.

The ease of starting businesses based on new home-grown technologies remains challenging, especially for women. Between 2002 and 2011, the number of women-owned businesses grew by 236%, outpacing male-owned businesses that grew by 153% (UBOS, 2002; Mugabi, 2014). However, even though women owned 44% of the business establishments in 2010/11 up from 39% in 2002, they were mainly engaged in self-employment. The majority of women-owned enterprises were concentrated in very few sectors (Figure 5), namely the trade (44%) sector; education, health and social work (49%); and accommodation and food services

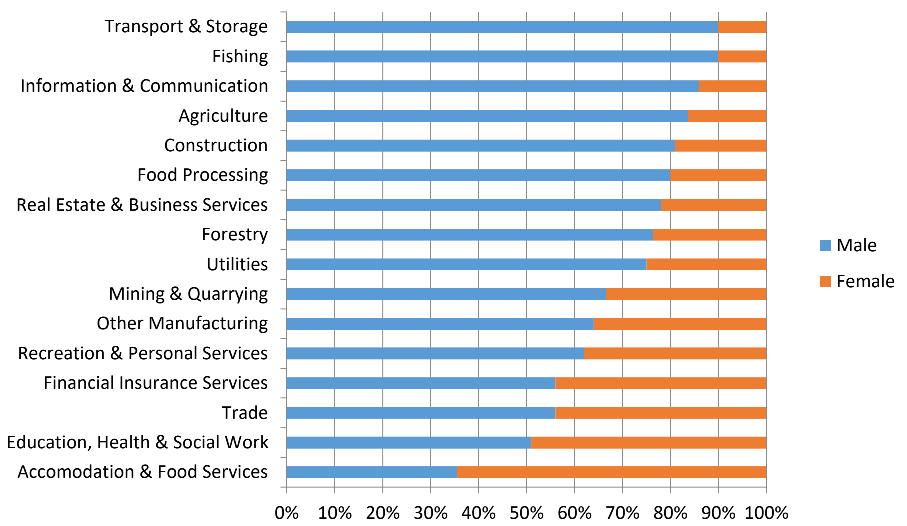
(65%), indicative of the strong influence of the predominant patriarchal culture in the Ugandan society where enterprises involving technical skills are traditionally 'male' dominated sectors.

The other point to note is that, although female workers were heavily involved in agricultural production (70-80%), only 0.4% of female-owned businesses (with fixed premises) were in the agriculture sector and women owned only 16.3% of all agricultural businesses. Women were mainly engaged in sectors traditionally perceived to be 'female'. Women entrepreneurs, like other entrepreneurs, were more likely to start businesses related to their knowledge, experience and skill base. If social roles, educational choices and labour market experiences are gendered, then the types of businesses started by men and women will reflect this differentiation. As well, women are more likely to start enterprises with low capital costs and barriers to entry because of their lower capacity to source external financing.

Results from an African #StartUpsurvey conducted in 2014 put Uganda on top of all the countries surveyed with 36.1% of female established businesses. Similarly Uganda was ranked the top performing country in Africa in terms of women entrepreneurship, with 34.8% of businesses owned by women in 2016 (MCF, 2016), with 90.5% of women borrowing and saving money to start a business, which was significantly higher than the 52.4% average of other low-to-lower-middle-income countries. Women entrepreneurial activity rate was 100% and labour force participation rate was 93.9%. Ugandan females also generally displayed a lower but consistently rising rate of early-stage entrepreneurial activity than males whose rate was somewhat variable from 2003 until 2012, when the total entrepreneurial activity (TEA) rates reached parity(Kelly *et al.,* 2012). However, Ugandan women were less likely than men to own an established business: 29% of adult women were established business owners, compared to 34% of adult men. The rates of early-stage entrepreneurial activity were the same among adult women as adult men at 25%, but women tended, more so than men, to be motivated to start a business out of necessity (because they have no other option for work) than opportunity (seeking independence or to improve, not just maintain, their income).

The growth in TEA rates among adult women may be a factor of their lesser opportunities to secure employment. If they want to earn a

Figure 5: Ownership of businesses by gender, 2010/11



livelihood or contribute to the family income, then entrepreneurial activity may be one of the only options available to them. Only 37% of women with new businesses had any employees, compared to 48% of men. For established business owners, only 38% of the women had employees versus 55% of the men. Six critical conditions are necessary for women to thrive in business: (i) gender-sensitive legal and regulatory system that advances women's economic empowerment; (ii) effective policy leadership and coordination for the promotion of women entrepreneurship development; (iii) access to gender-sensitive financial services; (iv) access to gender-sensitive business development support (BDS) services; (v) access to markets and technology; and, (vi) representation of women entrepreneurs and participation in policy dialogue. Increasing the role of women in innovation requires greater access to education, capital and markets to improve livelihood.

Promoting innovation for women requires supporting women in entrepreneurial development not only in micro and small scale enterprises but also large scale enterprises. This includes providing: advice and training; access to markets and financing; technology support in production and quality processes; representing women at senior management levels; and knowledge of business and intellectual property rights management. Very few dedicated supports are currently available to help women with growth potential to migrate to employer-businesses. One policy objective should be to identify, support and enable self-employed women with growth potential to achieve scale in their enterprise activity so they can create more employment opportunities. More effort is required to encourage women to enter into sectors with growth potential, through education, promotion of positive role models, financing, and a private sector and business climate that are open to women.

CONCLUSIONS AND RECOMMENDATIONS

Uganda recognises women's legal status and rights as cornerstones of inclusive growth and gender equality. National and local government structures support gender-focused governance, knowledge management and capacity building for gender equality. Capacity development for women in science is best promoted by building their knowledge through policies and actions promoting equal access to STEM education and training, and equal opportunity in the management and implementation of research. Broad science education preference policies do not seem to have helped girls and women much. The initiators of these policies have to understand and appreciate the need for affirmative action if women are to benefit more. The specific gender-focused conclusions and recommendations are as follows:

a) Several science education system-related factors, including effective policies to increase access to quality STEM education; teaching strategies and learning environments; assessment procedures and monitoring tools; and ICT-based technologies or approaches to reach more girls, build STEM literacy and skills, and address gender divides; gender roles and expectations on girls' participation, progression and learning achievement; family, peers and teachers, gender stereotypes in the media and the broader society, and educational resources - influence girls' aspirations, confidence and self-efficacy in STEM study and ST&I practice.
b) It is now universally accepted that countries and systems must more effectively pull girls into, and retain their interest in STEM studies and engagement in ST&I, including through mentors, role models, and extracurricular activities if genuine equitable development is to be attained. Empowerment, leadership and confidence as common drivers have to be imparted through existing and potential partnerships (e.g. cross-sectoral, public-private, parent-schools, counsellors-students,

industry-governments) to help advance gender-responsive STEM education and career advancement of women in ST&I. Cooperation is a win-win for girls and women.

c) The gender dimension must be incorporated in all national STI and other development/sector policies - especially linking the ST&I policies to policies on food and agriculture, water, energy, infrastructure and industry. Policy implementation has to be routinely tracked and assessed to ensure that policies benefit both men and women equally. Staff training in gender analysis in order to produce gender-sensitive policies, programming and impact evaluation, including development of skills in collecting gender-disaggregated information and analysis of data sets, and monitoring of policies and programmes, must be supported.

d) Developing and maintaining functional partnerships and collaboration among international and national research institutions and agencies, universities, nongovernmental organizations/civil society, government agencies and the private sector is critical to integrating gender perspectives and the inputs of women producers, scientists and innovators into ST&I for development.

e) The attrition rate is higher for girls than boys along the education pipeline. The progressively widening gender gap with higher levels of education and along urban-rural divides must be checked, through interventions that deepen the provision of incentives and opportunities to girls in the areas of health, livelihood and social support systems, to enable them stay in school and access life-long learning.

f) Gender gaps are more pronounced in the sciences than in the arts and humanities, and even widening in some fields. National support systems should be focused on gender-responsive innovations in technology that benefit everyone and mitigate new and emerging technologies widening old gaps and creating new ones.

g) The science preference policy in education and all other ST&I complimentary policies should integrate a gender lens, especially in their implementation, in order to: (i) encourage and support girls and women to realize their full potential; (ii) promote consultation with women concerning their technology needs and choices, and work with them to gain the knowledge, skills and resources to manage technology for their own purposes; and (iii) support the ability of women to participate actively in innovation systems and in key sectors.

h) Strengthening research in science and industrial leadership in innovation, including investment in key technologies, access to capital and support for SMEs is important in the application of ST&I to address societal challenges. Policy choices determine who benefits. Women's participation in decision-making at all levels, including through temporary special measures, and support policies and mechanisms that create an enabling environment for women's organizations and network has to be promoted.

i) Support for and scaling up of successful models and approaches through appropriate financial and policy measures, focusing on multi-stakeholder partnerships, and encouraging private sector and livelihood development to ensure the sustainability of initiatives is essential.

j) Uganda law and policy should continue to always ensure women's equal access to resources, education, extension and financial services, land and markets as part of overall support for their ST&I- and gender-related activities. The focus ought to be on three key questions around innovation, growth, and inequality: How can government and industry use existing technologies to deliver services more effectively and equitably to citizens? What are the best gender-sensitive mechanisms for creating and spreading new technologies to tackle shared problems? And, how can policymakers ensure that advances in technology (artificial intelligence, automation, and communications) bring shared benefits and not greater gender inequality?

k) Digital technologies and innovations are increasingly not only becoming an important avenue for training and knowledge acquisition, but also a means for women and girls to (i) overcome the barriers that they face across a variety of contexts, and (ii) achieve their goals and ambitions. There is need for a profound change in teaching methods and the curricula, and of more interconnected and multidisciplinary ways of learning science and technology as a means of promoting more creative and engaging ways to attract women to a career in science and technology.

l) A suite of well-funded support programmes for girls and women in STEM are needed – in the form of high school STEM awareness, mentoring programmes and scholarships for young women, particularly from less advantaged backgrounds. More cooperation is needed between the universities, the private sector and the state in developing a whole program that not only increases access for women to go into those fields, but supports them along their career path. Increasing the capacity of women and girls at the local level through appropriate information and education (formal and informal), training and technical support systems is essential.

m) Research and innovation institutions are key "transmission mechanisms" that are largely responsible for linking and disseminating the "global stock of knowledge" and skills among individuals, communities and enterprises. Women are underrepresented in tertiary ST&I education, research and industry. Representation, especially at strategic, decision-making levels is critical, both because it is important to have a diversity of viewpoints in the manner in which policy and programmes are designed and implemented at the national and local levels, and because participation builds leadership skills and visibility that helps members advance their careers. When women are prevented from reaching their full potential, the entire field suffers. Uganda needs 100% of the available brainpower to make the biggest impact and move ST&I forward as quickly as possible.

n) Talent management (attraction, recruitment, retention, development, and deployment) within the workspace should not continue to be "gender-blind" in the sense that it does not take into consideration gender roles and responsibilities of women and men, hence often unintentionally disadvantaging women. Working women ST&I professionals need additional support mechanisms focused on childcare, job and work time flexibility, funding, and career development initiatives. The imbalance in numbers of women needs to be corrected through genuine affirmative recruitment policies, women friendly working environments, and flexible work schedules that guarantee equal opportunity for retention and progression.

Science and technology must support women's development and livelihood activities, through solutions that achieve the overall objectives of interventions while closing relevant gender gaps in the process. Women can no longer be bypassed in ST&I policies and decisions, as this will not reflect their specific needs and concerns. It is imperative to: (i) support education, training and employment of women as scientists and professionals; (ii) ensure women's equal access to opportunities, resources, education, and services to support their ST&I- and gender-related activities; (iii) target technologies and other forms of support for developing income-generating activities to take into account the different needs of men and women; and, (iv) support the packaging of information and knowledge in a variety of formats to make it more accessible to women.

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STATEMENT OF NO-CONFLICT OF INTEREST
The authors declare that there is no conflict of interest in this paper

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