



Gendered assessment of Science, Technology and Innovation ecosystem: Case study of Agricultural Research and Training Institutions in Mali

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ABSTRACT

Availability of qualified human capital in sufficient quantity is necessary for the development and exploitation of science, technology and innovation. Mali, like many other African countries is striving to grow a requisite pool of skilled science, technology and innovation professionals but there is a dearth of information on the gender gaps at country level. Therefore, we conducted a gender-based assessment to map the status of science, technology and innovation upon which capacity development at higher education institutions will be premised. Primary and secondary data were collected and analysed qualitatively and quantitatively. The study looked at the following indicators of the status of science, technology and innovation: human capital, decision making, and research and development, while analysing the policy environment. All the indicators assessed exhibited large gender imbalance in favour of men. Within the agricultural research and training institutions, women are largely under-represented [15%]. Among women researchers, only 8% were active in 2018 compared to 92% for men. Eighteen percent of the staff involved in decision making were women compared to 82% for men. Among the active researchers, very few [6%] accessed science, technology and innovation information, regardless of gender indicating that this is a general issue that must be tackled at all level. To correct the gender gap in the agricultural training and research institutions, a capacity building program based on a countrywide policy of mainstreaming gender with incentives for girls in education, starting from the level of preschool, to primary, secondary, tertiary and high school, to higher education should be considered. Such gender mainstreaming program should be developed, implemented and must be accompanied by a strong and rigorous monitoring and evaluation program, to help inform policies on a regular basis. The gender mainstreaming programs should also provide incentives to girls that promote excellence in the short, medium and long terms.

Keywords: Agricultural training and research, gender imbalance, Mali, Science Technology and Innovation, Women

RÉSUMÉ

La disponibilité d'un capital humain qualifié en quantité suffisante est nécessaire au développement et à l'exploitation de la science, de la technologie et de l'innovation. Le Mali, comme de nombreux autres pays africains, s'efforce de développer un réservoir de professionnels qualifiés en science, technologie et innovation, mais il y a un déficit d'informations sur les écarts de genre dans les sciences, technologies, et innovation au niveau des pays. Par conséquent, nous avons mené une évaluation sexospécifique pour cartographier l'état de la science, de la technologie et de l'innovation sur lequel le développement des capacités dans les

établissements d'enseignement supérieur sera fondé. Des données primaires et secondaires ont été collectées et analysées qualitativement et quantitativement. Plus précisément, l'étude a examiné les indicateurs suivants de l'état de la science, de la technologie et de l'innovation: capital humain, prise de décision et recherche et développement, tout en analysant l'environnement politique. Tous les indicateurs évalués ont montré un important déséquilibre de genre en faveur des hommes. Au sein des institutions de recherche et de formation agricoles, les femmes sont largement sous-représentées [15%]. Parmi les femmes chercheuses, seulement 8% étaient actives en 2018 contre 92% pour les hommes. Dix-huit pour cent du personnel impliqué dans la prise de décision étaient des femmes contre 82% pour les hommes. Parmi les chercheurs actifs, très peu [6%] ont accédé aux informations sur les sciences technologies et innovations, quel que soit leur genre, indiquant qu'il s'agit là d'un problème général qui doit être abordé à tous les niveaux. Pour corriger les écarts de genre dans les sciences, technologies, et innovations, un programme de renforcement des capacités basé sur une politique nationale d'intégration systématique de la dimension genre avec des mesures incitatives pour les filles dans l'éducation, du niveau préscolaire à l'enseignement supérieur, en passant par l'enseignement primaire, secondaire et tertiaire, devrait être envisagé. Ce programme d'intégration de la dimension genre doit être élaboré, mis en œuvre et accompagné d'un programme de suivi et d'évaluation solide et rigoureux, pour contribuer à éclairer régulièrement les politiques. Ces programmes d'intégration de la dimension de genre devraient fournir des incitations aux filles qui promeuvent l'excellence à court, moyen et long terme.

Mots-clés: femmes, science, technologie et innovation, déséquilibre entre les sexes, formation et recherche agricoles

INTRODUCTION

Science, Technology and Innovation [STI] ecosystems comprise public institutions, academia, and the private sector at the local, national and regional levels, all functioning within a well coordinated policy environment and well integrated within the global context [Madar *et al.*, 2018]. Globally, it has been recognised that Science, Technology and Innovation [STI] is a key driver of the economic and social development [United Nations 2010, 2017]. The majority of the 17 SDGs of the United Nations require technology and innovation for their implementation and achievement [Soumitra *et al.*, 2018]. Countries that have invested in STI have benefited considerably in terms of economic growth, environmental advantages, and improved livelihoods. In the 2018 Global Innovation Index [GII], high income economies such as

Switzerland and Sweden that ranked highest for their innovation input sub index also ranked highest in terms of innovation outputs and efficiency ratio [Soumitra *et al.*, 2018]. The Kingdom of the Netherlands did better, ranking 9th for the innovation input sub index but second in terms of outputs, with high efficiency ratio. The same situation applies to upper middle income economies such as China, Malaysia, and Bulgaria, to lower middle income economies such as Ukraine, Vietnam, and Moldova and also to low income economies such as Tanzania, Senegal, and Mozambique [Soumitra *et al.*, 2018].

Among the five pillars of innovation input sub-index (Institutions, Human capital and research, infrastructure, Market sophistication, and Business sophistication) that are used to assess the Global Innovation Index [GII],

human capital and research play an important role. Thus, availability of qualified human capital in sufficient quantity is necessary for the development and exploitation of STI. The Human Capital Index is a measurement that the World Bank uses to assess which countries are best in mobilizing the economic and professional potential of their citizens.

A linear positive and statistically significant relationship has already been reported between country population size and the GII, at least for high income economies [Soumitra *et al.*, 2018]. Although this has not yet been confirmed for low economy countries like Mali, it is worthwhile comparing Mali's human capital index with that of countries that are doing well in terms of GII. Such comparisons revealed that high income economies like Switzerland, Sweden, and Netherlands ranked 3rd, 6th, and 8th, respectively in terms of human capital index, compared to Mali which ranked 118th [World Economic Forum, 2015]. The same trend was observed when Mali is compared with other low income countries [Tanzania, Senegal and Rwanda]. Comparison of Mali with the above countries in terms of GII ranking and human capital index gave the same picture in 2018.

To exploit its population potential estimated at 18.3 million inhabitants among which 50.64% are women [INSTAT, 2018 and 2014] for the benefit of STI, Mali like other African countries must invest in and leverage its human resources. During this process, countries must ensure that women who represent the majority of the population are involved.

Mali has been participating in the African Science, Technology and Innovation Initiative [ASTII] since 2007. The last assessment of its STI status conducted in 2017 was mainly focused on documenting indicators such as human capital, financial resources and the innovations offered by STI stakeholders [INSTAT, 2017]. The study highlighted the weak representation

of women in the STI human capital, being only 23%, indicating a two-fold increase compared to 2015. However, the study did not include gendered data for other indicators such as access to information and decision making. Nonetheless, gender is a global issue cutting across most of the 17 SDGs of the United Nations. The United Nations Conference on Trade and Development (2011) reported that the needs, concerns, and interests of men and women should be addressed in all policies related to science, technology and innovation. Therefore, applying a gender lens to STI studies is necessary to gather gender disaggregated information relevant to policy makers for the design of policies and programs that support the equitable development of men and women.

The overall objective of the study was to conduct a gender-based assessment of STI ecosystem in Mali to scientifically document the status of STI upon which capacity development at higher education institutions will be premised. Specifically, the study looked at the following indicators of the status of science, technology and innovation: Human capital, Decision making, and Research and development, while analysing the policy environment.

MATERIALS AND METHODS

Population and sample selection. Components of the STI ecosystem that were targeted included research and training institutions from both public and private sectors and private sector industries. Within the targeted STI ecosystem components, cases studies of agricultural higher education and research institutions were conducted. The National Center of Scientific and Technological Research [CNRST] which is the national coordinating body of STI in Mali, has listed 49 STI institutions among which seven (14.3%) are in agriculture and/food security/safety. Out of the seven public sector institutions involved in agricultural research and/or training, three were interviewed [42.85%]. From the private sector side, and in the absence of information on the

base population, two institutions were selected for the case study.

Data collection and analysis. This survey used both primary and secondary data. For primary data collection, a standard questionnaire was used. The questionnaire was sent to stakeholders for filling and relayed back electronically. Three groups of indicators were measured using gender lens, these included: human capital (quantity, quality, and staff promotion), decision making, and research and development (active researchers, access to STI information). Data were descriptively analysed in Microsoft excel.

RESULTS

Status of women in Mali. In Mali, women are traditionally assigned reproductive, social, and productive roles. In their reproductive roles they are known as spouses and mothers. As such, they are in charge of all domestic tasks. In the society, they are responsible for ensuring that the traditions in the family and in the community are perpetuated generation after generation. To have a good image, women must fully accomplish the reproductive and social roles. In addition they must accomplish productive roles to contribute to the economic development of the family, the community and the country. Malian women must accomplish these roles no matter whether they are living in rural or urban settings, or have received or not received formal education (Association pour le progrès et la Défense des Droits des Femmes, 2000).

Women account for more than 50% of the Malian population. Among all government employees, only 25.6% were women (Association pour le progrès et la Défense des Droits des Femmes, 2000). Malian women are 50.4 percent of the poorest of the poor (Observatoire du Développement Humain Durable et de la Lutte contre la Pauvreté, 2006). A good 91.3% of rural women are involved in agriculture and livestock, as primary source

of income and livelihoods [CPS, 2006]. They are especially found in the lowland rice (*Oryza* sp), cowpea (*Vigna inguiculata* L.), groundnut (*Arachis hypogaea*), fonio (*Digitaria exilis*), sesame (*Sesamum indicum*) and vegetable value chains and active in the production, processing and value-adding segments, and trading. However, only 3% of farm managers in Mali are women [CPS, 2006]. Women in Mali face restricted agricultural land access, with only 15 percent of the State improved lands allocated to them, as per the Law adopted by the National Assembly on April 11, 2017. When they are legally employed, Malian women are largely found in the areas of social services and human resources management (Association pour le progrès et la Défense des Droits des Femmes, 2000).

In 2015, only 49.8% of the girls were enrolled at the level of secondary education [INSTAT, 2018]. They are also found in higher education, though in lower quantity [Table 1]. Although the involvement of women in decision-making is vital for achieving tangible results for economic growth, in 2016, only, 9.5% of the parliamentarians were women [INSTAT, 2018]. According to the Institute of National Statistics, women were 23% of STI human capital in Mali in 2017. This figure corresponded to a two-fold increase compared to 2015 figure. From the present study, there are about 100 women involved in teaching and research in the STI arena in Mali. They network through Women Teachers and Researchers of Mali –REFUEMA where they communicate, share information and establish partnership with each other.

Policy environment. Respect of human's rights in general and equality between men and women in particular, is a fundamental value in the country's constitution adopted in February 25, 1992. This constitution in its article 2 prohibits all discriminations based on gender [Table 2]. A gender policy was developed, aligned with the constitutional values and

Table 1. Gendered status of students in Higher Educational Institutions in Mali in 2018 – Case study of IPR/IFRA and the Faculty of Social sciences of the University of Ségou –US/FASSO

| Name of institution | Number of students in 2018 | | Percentage of students in 2018 | |
|---|----------------------------|------|--------------------------------|-----|
| | Women | Men | Women | Men |
| University of Ségou, Faculty of Social Sciences - | 649 | 1449 | 13 | 29 |
| Polytechnic Rural Institute for Training and Applied Research | 608 | 2298 | 12 | 46 |
| Total | 1257 | 3747 | 25 | 75 |

adopted in 2011. The gender policy envisions a democratic society which guarantees the development of all women and men through the full exercise of their fundamental equal rights, active and participative citizenship and equitable access to resources.

The country also adopted an Institutional Development Policy [Table 2] which emphasizes State reforms that promote investments in specific niches required for advancing gender mainstreaming as a principle of governance. The Ministry of Promotion of Woman, Child and Family is a member of the State Reform Monitoring Committee, which is chaired by the Prime Minister. A ministry for the promotion of Women, Children and Family has also been created and is controlled by women. Most sectoral and sub sectoral development policies and programs have a gender component to ensure equal representation of men and women at all levels [Table 2]. The country is signatory to many regional and international conventions that promote gender equalities at all levels [Table 2].

Mali's policy on higher education and scientific research was adopted in 2009. This policy aims among other objectives at reducing inequalities between people and regions and promoting men and women. The country has also an STI policy adopted in 2016. This STI policy in its axis 4, intends to build and nurture an STI

culture that would encourage girls and women to embrace Science Technology Engineering and Mathematics (STEM). The policy also envisioned, among others, to increase staff quantity, quality and their working conditions. However, this policy has not been particularly clear about the gender dimension of staff quality and quantity, especially how to increase the involvement of women scientists.

Human capital involved in STI eco-system in Mali: Case of agriculture and related fields *Staff quantity*. The number of staff involved in STI in the field of agriculture in 2018 was 922, out of whom only 15% were women [Table 3]. The majority of agricultural sector STI human capital comes from the public sector (94.68%). However, this figure should be taken with caution, due to the fact that only two private sector institutions were involved in the study. These two institutions used as case studies had 49 staff with 36.73% being women. The two training and research institutions accounted for 194 staff out of 922 [21.04%] whereby the leading agricultural research institution – IER accounted for 679 staff [73.64].

***Staff quality*.** Large inequalities were recorded between men and women for all staff categories. Out of the 302 master degree holders, only 10% were women. When we consider the institutions individually, the number of master holders gave similar patterns. For some institutions, women

Table 2. National and Sectoral Policy instruments on gender and STI in Mali

| Sector / Subsector | Policy and year effective | Gender provisions | Year (s) revised |
|--------------------|--|---|--|
| Governance | Constitution of the Republic of Mali (February 25, 1992) | Article 2: Prohibition of all discriminations based on gender | |
| | Institutional Development Policy (IDP, 2003) | IDP emphasizes State reforms that promote investments in specific niches required for advancing gender mainstreaming as a principle of governance. The Ministry of Promotion of Woman, Child and Family is a member of the State Reform Monitoring Committee, which is chaired by the Prime Minister. | |
| | National Gender Policy (2011) | Vision: <i>A democratic society which guarantees the development of all women and men through the full exercise of their fundamental equal rights, active and participative citizenship and equitable access to resources.</i> | |
| | ECOWAS Gender Policy | This policy commits all ECOWAS member States, including Mali, to: <ul style="list-style-type: none"> - Create an environment conducive to gender equality and equity with a view to achieving sustainable development - Strengthen the participation and role of women as leaders in policy, governance and decision-making - Promote equitable access to quality education and address the social and cultural concerns of women - Reorient public resources to address issues of gender equality and equity, thereby promoting the formation of significant human capital and strong economic growth. | |
| | International convention for the elimination of all forms of discriminations of women endorsed by Mali in September 1985 | Article 3: “In all fields, including political, social, economic and cultural, take all appropriate measures, including legislative provisions, to ensure the | Additional protocol ratified by Mali in September 2000 |

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|---------|--|---|--|
| | | full development and advancement of women, with a view to guaranteeing the exercise and enjoyment of the human rights and fundamental freedoms on the basis of equality with men” | |
| | Beijing action plan adopted in 1995 | Member States integrate the dimension of equals between women and men as a principle of law and good governance while focusing their efforts on 12 priority areas for action among which education and training, and decision making | |
| | African Charter on Human and Peoples’ Rights (June 21, 1981) | Optional Protocol on the Rights of Women in Africa. The Solemn Declaration of African Heads of State on Equality Between women and men (Addis Ababa, July 2004) lays down the principle of parity between men and women in decision-making | |
| | Africa’s Youth Charter (July 2006) | Article 2. Sets out the principle of equal rights and freedoms without discrimination based on gender Article 25 Sets out specific measures to remove the discrimination that affects girls and young women in terms of fundamental rights, civic participation, education, and health, and etc. | |
| Economy | Strategic Framework for Growth and Poverty Reduction (SFGPR, 2007-2011) | A section of the SFGPR describes issues related to inequalities between women and men in the various sectors while highlighting the socio-cultural factors that perpetuate these inequalities. | 2012-2017 (Strategic Framework for the Fight against Poverty) 2016-2018 (Strategic Framework for Economic Recovery and Sustainable Development) |
| | Millenium Development Goals (MDGs) adopted by 191 countries including Mali in September 2000 | MDG-3 addresses the promotion of gender equality and the empowerment of women in two points: (i) Eliminate gender disparities in primary and secondary education, preferably by 2005 and at all levels of education no later than by 2015; (ii) Reduce gender disparities in economic and | |

political life. The expected progress towards the MDGs requires Member States to consider the elimination of gender disparities and inequalities in development policies and programs.

| | | |
|---|--|---|
| Agriculture | Agriculture Orientation Law (AOL, August 2006) | <p>Article 6: AOL takes into account the sub-regional and international commitments made by Mali and these includes all the commitments related to the abolishment of all gender inequalities</p> <p>Article 45: The Government promotes equity between women and men in rural areas, in particular in farming.</p> |
| | Agriculture Development Policy (ADP, August 2013) | <p>Section 4.2.4 Puts emphasis on capacity building of women and youth</p> |
| Higher Education | National Higher Education and Scientific Research Policy (NHESRP, December 2009) | <p>Section on Objectives, the preamble:</p> <ul style="list-style-type: none"> - Reducing inequalities between people and regions - Promotion of men and women |
| Science Technology and Innovation (STI) | National STI policy (2017 – 2025) | <p>Section on Specific objectives:</p> <ul style="list-style-type: none"> - Training of young people, girls, and women, in order to better ensure the equity of training and education in science is high in the agenda of the national STI policy. - This is expected to occur at all levels of education from the primary, secondary and university levels, as well as in technical schools and institutions, and continuing education <p>Axis 4: Promotion of a culture of STI</p> <ul style="list-style-type: none"> - Create incentives for girls to embrace Science Technology Engineering and Mathematics (STEM) |

Table 3. Staff quantity per institution and per gender in 2018 in Mali

| Name of institution | Total staff | | | Percentage of total staff | | |
|---|-------------|-----|-------|---------------------------|-------|-------|
| | Women | Men | Total | Women | Men | Total |
| University of Ségou, Faculty of Social Sciences | 3 | 18 | 21 | 0.33 | 1.95 | 2.28 |
| Institute of Rural Economy | 80 | 599 | 679 | 8.68 | 64.97 | 73.64 |
| Polytechnic Rural Institute for Training and Applied Research | 37 | 136 | 173 | 4.01 | 14.75 | 18.76 |
| Point Sud Centre for Local Knowledge | 2 | 15 | 17 | 0.22 | 1.63 | 1.84 |
| PROSLABS - Microbio Consulting | 16 | 16 | 32 | 1.74 | 1.74 | 3.47 |
| Total | 138 | 784 | 922 | 14.97 | 85.03 | 100 |

MSc holders are 30 times fewer than men [Table 4]. The PhD holders totalled 102 staff, 12% of whom were women. The number of PhD holders was almost similar for IPR/IFRA and IER, 59 and 56, respectively. Importantly, a similar trend in women representation in these two institutions where women were 29.5 and 7 times less than men was observed [Table 4]. When we considered the technical staff involved in STI, the number of women in the case studies was only 21 out of 185 [11%]. The case of IER [3.85% of women technicians] is of a greater concern, because this is the leading agricultural research institution in the country. Regarding the STI support staff at the institutions in the case studies, the situation is better with 35.54% women [Table 5].

Staff promotion per gender. Staff promotion events were hardly found in the case studies during the period concerned [2018]. The only promotion events occurred at IER which promoted 46 staff in 2018. We find these figures again below the requisite numbers for achieving gender equality, women representing only 15% [Table 6]. Involvement of women at leadership positions is paramount in achieving gender equality and problem solving in a society. Nonetheless, the case studies of Mali indicated that STI and higher education institutions are far from achieving gender equality for decision

making since only 22% of women were involved in decision making at their institutions [Table 7].

Research and development

Number of active researcher in 2018. Our investigations revealed that only 22 women [7.75%] were active researchers in 2018 out of a total of 284 [Table 8]. The majority of the active researchers came from IER (88%) followed by IPR/IFRA (7%) and Point Sud Centre for Local Knowledge (5%) (data not shown). When it comes to gender, IPR/IFRA did better with 40% of its active researchers being women (data not shown).

Access to STI information in 2018. Access to STI information such as financing opportunities, conferences and symposia, scientific publications, publishing partners, information on IPR issues, partnership opportunities or new technologies for all researchers [both men and women] is paramount for them to be productive and make meaningful contributions to STI. Like other indicators, parity between men and women is a must. Unfortunately, our investigations showed that out of the 22 women researchers who were active in 2018, only four [18%] accessed STI information [data not shown]. Comparison of women and men for parity check yielded a large gender gap, men being 78% and women 22% among active researchers

who accessed STI information in 2018 [Table 9]. From the side of the men researchers who were active in 2018, only 14 accessed STI information, which corresponded to only 5% [data not shown]. This weak performance of men in access to STI information shows that this is a serious gap that is not gender specific and that must be addressed properly, for all genders.

DISCUSSION

Meaningful exploitation of science, technology and innovation requires among others, the availability of a critical mass of human capital skilled in Science, Technology, Engineering and Mathematics [STEM]. Similarly Murphy *et al.* (1991) who reported that countries with higher proportion of human capital skilled in

the area of STEM tend to grow faster compared to countries with higher proportion of human capital skilled in other disciplines. This is also consistent with the UNESCO Institute for Statistics (2015) which showed that the number of researchers per capita was 117 times greater for Switzerland (a high income country) compared to Mali. The same applies to BRICS countries such as China and Brazil, where the per capita researcher head counts were 23 and 18 times greater than for Mali, respectively.

In this survey, 922 staff were involved in the design and implementation of STI policies, programs and projects. Compared to the 18.343 million inhabitants in Mali, this corresponded to 51 STI staff per million

Table 4. Number of STI staff per degree of training and gender in Mali in 2018 –Master and PhD

| Name of institution | MSc Holders-[Number] | | MSc Holders [%] | | PhD holders [Number] | | PhD holders [%] | |
|---|----------------------|------------|-----------------|--------------|----------------------|------------|-----------------|-----------|
| | Women | Men | Women | Men | Women | Men | Women | Men |
| University of Ségou, Faculty of Social Sciences | 0 | 13 | 0 | 4.30 | 0 | 4 | 0.00 | 3.92 |
| Institute of Rural Economy | 6 | 180 | 1.99 | 59.60 | 8 | 56 | 8.00 | 54.90 |
| Polytechnic Rural Institute for Training and Applied Research | 16 | 64 | 5.30 | 21.19 | 2 | 59 | 2.00 | 57.84 |
| Point Sud Centre for Local Knowledge | 1 | 6 | 0.33 | 1.99 | 1 | 6 | 1.00 | 5.88 |
| PROSLABS - Microbio Consulting | 6 | 10 | 1.99 | 3.31 | 1 | 2 | 1.00 | 1.96 |
| Total | 29 | 273 | 9.60 | 90.40 | 12 | 127 | 9 | 91 |

Table 5. Number of STI staff per degree of training and gender in Mali in 2018 – Technicians and Support staff

| Name of institution | Technicians [Number] | | Technicians [%] | | Support staff [Number] | | Support staff [%] | |
|---|----------------------|------------|-----------------|--------------|------------------------|------------|-------------------|--------------|
| | Women | Men | Women | Men | Women | Men | Women | Men |
| University of Ségou, Faculty of Social Sciences | 1 | 1 | 0.54 | 0.54 | 2 | 0 | 0.68 | 0 |
| Institute of Rural Economy | 6 | 156 | 3.24 | 84.32 | 60 | 207 | 20.27 | 70 |
| Polytechnic Rural Institute for Training and Applied Research | 9 | 3 | 4.86 | 1.62 | 10 | 10 | 3.38 | 3 |
| Point Sud Centre for Local Knowledge | 0 | 0 | 0.00 | 0.00 | 0 | 3 | 0 | 1 |
| PROSLABS - Microbio Consulting | 5 | 4 | 2.70 | 2.16 | 4 | 0 | 1.35 | 0 |
| Total | 21 | 164 | 11.35 | 88.65 | 76 | 220 | 25.68 | 74.32 |

inhabitants. This figure is slightly lower than the 64 researchers per million inhabitants reported by UNESCO (2015). When we looked at the staff actually involved in research (MSc, PhD and Technicians), this figure dropped to 34.78 staff per million inhabitants. But Mali's population is composed of approximately 50% women. Applying a gender lens at key components of STI ecosystem in Mali showed that gender imbalance is present in all the indicators we assessed namely (i) staff quantity, (ii) staff quality [PhD, MSc, technicians, and support staff], (iii) staff promotion and access to leadership positions, (iv) staff involvement in decision making, (v) number of active researchers, and (vi) access of researchers to

STI information. For all of these indicators, the survey revealed large under representation of women as compared to men.

Staff quantity has been found largely unbalanced in favour of men (85%) in our cases studies. This figure, though in agreement with respect to the pattern in gender imbalance, is slightly higher than the 77% reported by the national Institute of Statistics in 2017. It should be emphasised that the survey of INSTAT in 2017 had a much broader coverage (156 private enterprises plus all the research institutions of the country) compared to ours which was limited only to five case studies of agricultural STI institutions. Thus our survey has established that agricultural

training and research institutions have higher level of women under-representation in STI than the average of all STI fields combined across Mali. It looks like that while women farmers dominate in agricultural value-chains, women scientists fall into the minority groups at the level of agricultural training and research institutions in Mali. Many efforts are needed to correct this gender gap if the country is to meaningfully exploit the potential of women human capital to boost its economic growth and sustainable development. Leaving behind unexploited such potential is a big loss for Mali which the country cannot afford. The same situation has been observed among students enrolled in higher education institutions in 2018, with only 25% of the enrolled students being female [Table 1]. This result indicates that the gender imbalance in STI staff quantity is likely to remain for the coming or more years if nothing is done to increase the enrolment of girls in higher education institutions in the field of agriculture.

Staff quality is also important. In this survey only 10% and 11% of the staff involved in STI were women MSc and PhD holders, respectively [Table 5]. Likewise, only 11% and 26% of the staff were women technicians and support staff, respectively. Thus increasing the number of women and girls in higher education institutions is needed to fill the gap. However, this should be done under a countrywide policy of mainstreaming gender in education, starting from the level of preschool, to primary, secondary, tertiary and high school, to higher education. Such gender mainstreaming program should be developed, implemented and should provide incentives for girls and women that promote excellence at short, medium and long terms. They must be accompanied by a strong rigorous monitoring and evaluation program, to help inform policies on a regular basis.

Regarding staff promotion to access leadership position and involvement in decision making, the survey revealed that such an event hardly

happens at the institutions in the case studies. Only IER had promoted its staff in 2018, and among the promoted staff, 15% were women [Table 4]. This result is not surprising, given the low representation of women at IER. Indeed, the number of promotion depends on the number of staff available. Once again a countrywide gender mainstreaming program is necessary to fill this gender gap.

Availability of research staff at an institution cannot guarantee alone the development of STI in terms of research outputs, outcomes, and impacts. The researchers must be active, and to be active they must access STI information such as financing opportunities, conferences and symposia, scientific publications, publishing partners, information on IPR issues, partnership opportunities or new technologies in their respective fields. When we looked at the number of researchers who were active in 2018 [Tables 8 and 9], the gender gap was imbalanced in favour of men (82%). The same trend was observed for the indicator “access to STI information”. Among the researchers who were active in 2018, only 18% and 5% accessed STI for women and men, respectively [data not shown]. The poor performance of men and women in accessing STI information on one hand, and the weaker performance of men compared to women in the access to STI information shows that this is a serious gap in the Malian context of STI that is not gender specific and that must be addressed properly, for all genders. Large efforts need to be made here to facilitate access of all researchers to STI information. Although access to STI information in Mali is not well documented, the need for its improvement is well known to Malian authorities since this is the focus of the national STI policy, strategic axis #7 and action #4.

CONCLUSION

Agriculture is the driving force for Mali's economic development and growth. It is for this reason that the authorities have allocated 15% of the country's budget to this sector.

Table 6. Status of STI staff promotion per gender in 2018 in Mali

| Name of institution | Number of STI staff promoted | | Percentage of STI staff promoted] | |
|---|------------------------------|-----|-----------------------------------|-------|
| | Women | Men | Women | Men |
| University of Ségou, Faculty of Social Sciences | 0 | 0 | 0 | 0 |
| Institute of Rural Economy | 7 | 36 | 15.22 | 78.26 |
| Polytechnic Rural Institute for Training and Applied Research | 0 | 3 | 0.00 | 6.52 |
| Point Sud Centre for Local Knowledge | 0 | 0 | 0 | 0.00 |
| PROSLABS - Microbio Consulting | 0 | 0 | 0.00 | 0.00 |
| Total | 7 | 39 | 15.22 | 84.78 |

Table 7. Number of staff in decision making per institution and per gender in 2018 in Mali

| Name of institution | Number of STI staff at a decision making position | | Percentage of STI staff at a decision making position | |
|---|---|-----|---|-------|
| | Women | Men | Women | Men |
| University of Ségou, Faculty of Social Sciences | 0 | 0 | 0 | 0 |
| Institute of Rural Economy | 0 | 7 | 0 | 25.00 |
| Polytechnic Rural Institute for Training and Applied Research | 1 | 8 | 3.57 | 28.57 |
| Point Sud Centre for Local Knowledge | 0 | 4 | 0 | 14.29 |
| PROSLABS - Microbio Consulting | 4 | 4 | 14.29 | 14.29 |
| Total | 5 | 23 | 17.86 | 82.14 |

Table 8. Gendered status of Research at STI institutions in 2018 in Mali- Number of active researchers

| Name of institution | Number of active researchers | | Percentage of active researcher | |
|---|------------------------------|-----|---------------------------------|-------|
| | Women | Men | Women | Men |
| University of Ségou, Faculty of Social Sciences | 0 | 0 | 0.00 | 0.00 |
| Institute of Rural Economy | 10 | 240 | 3.52 | 84.51 |
| Polytechnic Rural Institute for Training and Applied Research | 8 | 12 | 2.82 | 4.23 |
| Point Sud Centre for Local Knowledge | 4 | 10 | 1.41 | 3.52 |
| PROSLABS - Microbio Consulting | 0 | 0 | 0.00 | 0.00 |
| Total | 22 | 262 | 7.75 | 92.25 |

Table 9. Access of staff to STI information in 2018 per institution and gender in Mali

| Name of institution | Number of STI staff accessing STI information in 2018 | | Percentage of STI staff accessing STI information in 2018 | |
|---|---|-----|---|-------|
| | Women | Men | Women | Men |
| University of Ségou, Faculty of Social Sciences | 0 | 2 | 0.00 | 11.11 |
| Institute of Rural Economy | | | 0.00 | 0.00 |
| Polytechnic Rural Institute for Training and Applied Research | 0 | 0 | 0.00 | 0.00 |
| Point Sud Centre for Local Knowledge | 4 | 12 | 22.22 | 66.67 |
| PROSLABS - Microbio Consulting | 0 | 0 | 0.00 | 0.00 |
| Total | 4 | 14 | 22 | 78 |

This survey has established the benchmarks for critical indicators linked to the design and implementation of STI policies, programs and projects for sustainable agricultural development. All indicators were benchmarked while applying gender lenses and agricultural training and research institutions were found to harbour in-depth gender imbalance in favour of

men as compared to agricultural value-chains which generally involve more women farmers than men producers. To address the gender imbalance found in all the indicators we studied, it is recommended to develop and implement a countrywide program to mainstream gender in agricultural training and employment institutions.

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STATEMENT OF NO-CONFLICT OF INTEREST

The authors declare that there is no conflict of interest in this paper.

REFERENCES

- Association pour le Progrès et la Défense des Droits des Femmes Maliennes. 2000. *La Femme au Mali – Livre Blanc : Cadre de vie, problèmes, promotion, organisations*, Friedrich Ebert Stiftung, Bamako, Mali. 123pp.
- Cellule de Planification et de Statistique. 2006. *Recensement General De L'Agriculture (RGA) Campagne Agricole 2004-2005, Résultats Définitifs, Volume II: Rapport Détaillé*, République du Mali, Ministère de L'Agriculture, Ministère De L'Elevage et de la Pêche, Ministère du Plan et de L'Aménagement du Territoire, Bamako, Mali.
- Institut National de la Statistique. 2014. *Enquête modulaire et permanente auprès des ménages : Rapport d'analyse*, Premier passage Bamako, Mali. 76pp.
- Institut National de la Statistique. 2017. *Enquête nationale de la Science, Technologie et Innovation en 2017 au Mali : Rapport d'analyse*, Ministère du Plan et de l'aménagement du Territoire, Bamako, Mali. 75pp.
- Institut National de la Statistique. 2018. *Le Mali en chiffres de 2012 à 2016*. Institut National de la Statistique du Mali, Bamako, Mali. 28pp.
- Madar, M.J., Baqutayanb, S.M.S. and Subari, M.D.B. 2018. Science, technology and innovation (STI) policy reform for developing countries at the grassroots. *Journal of Science, Technology, and Innovation Policy* 5 (1): 1-5.
- Ministry of Higher Education and Scientific Research. 2009. *Document de politique nationale de L'enseignement supérieur et de la recherche scientifique*, Bamako, Mali. 24pp. https://planipolis.iiep.unesco.org/sites/planipolis/files/ressources/mali_politique_nationale_enseignement_superieur.pdf
- Ministry of Higher Education and Scientific Research. 2016. *Document de politique nationale de L'enseignement supérieur et de la recherche scientifique*, Bamako, Mali. 41pp. <http://dg-enseignementsup.ml/wp-content/uploads/2019/10/Politique-Nationale-de-la-Science-de-la-Technologie-et-de-Innovation.pdf>
- Ministry of Woman, Child, and Family. 2011. *National Gender Policy*, Bamako, Mali. http://www.passip.org/passip_intranet/pdf-intranet/Politique/9-41%20Politique%20Nationale%20Genre_2011.pdf
- Murphy K. A., AShleifer, A. and Vishny, R. 1991. The allocation of talent: Implications for growth. *Quarterly Journal of Economics* 106: 503 – 530.
- Seydou Loua. 2017. Les grandes réformes de l'école malienne de 1962 à 2016, *Revue internationale d'éducation de Sèvres* 75: 34-40. <https://journals.openedition.org/ries/5917#quotation>
- Soumitra D., Bruno L. and Wunsch-Vincent, S. 2019. *The Global Innovation Index 2019: Creating Healthy Lives - The Future of Medical Innovation*. Cornell University, INSEAD, and WIPO; Ithaca, Fontainebleau, and Geneva. 451pp.
- Soumitra, D., Rafael, E. R., Antanina G., Kritika, S., Bruno, L., Wunsch-Vincent, S., Lorena, R. L. and Francesca, G. 2018. *The Global Innovation Index 2018*. Chapter 1-

- Energizing the world with innovation. GII, Cornell University, Ithaca, NY. 52pp.
- UNESCO. 2015. UNESCO Institute for Statistics, Montréal, Canada. UNESCO
- United Nations. 2017. New innovation approaches to support the implementation of the sustainable development goals. United Nations Conference on Trade and Development, UN, New York and Geneva. 51pp.
- United Nations. 2010. Science, Technology and Policy Review: Mauritania. United Nations Conference on Trade and Development, UN, New York and Geneva. 148pp.
- United Nations Conference on Trade and Development. 2011. Applying a gender lens to science, technology, and innovation. Current studies on science technologies and innovation, No5. United Nations, New York and Geneva. 73pp.
- World Economic Forum. 2015. The Human Capital Index Report. World Economic Forum. 319pp. http://www3.weforum.org/docs/WEF_Human_Capital_Report_2015.pdf