
Building science skills to improve the contributions of women to agricultural research and development in Sub-Saharan Africa

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Abstract

Building the capacity of African women scientists to raise their contributions to agricultural research and development is critical to ensuring food security in sub-Saharan Africa. The African Women in Agricultural Research and Development program developed a tailored capacity development program to contribute to this. We discuss the rationale and theory of change for the program, as well as the extent to which participants demonstrated science-related outcomes, including capabilities to: conduct research, conduct gender responsive research, fundraise, and to present research findings. This paper evaluates the effectiveness of the program on a sample of 122 women. Results show increased capacity on each of the outcomes from before to after the program. Most participants (93 percent) indicated that program played a strong role in the changes they experienced. Qualitative analysis confirmed this in all the cases. Key lessons for the design and implementation of women's science capacity development programs are highlighted.

Keywords: Science skills development, agricultural research and development, capacity building, innovations, gender

Introduction

One of the drivers for the increased representation of women in science is the premise that diversity stimulates innovation and improved organizational outcomes. Evidence supports this assumption (Duran and Lopez, 2015; Hewlett, Marshall and Sherbin, 2013) and the unique contributions that women make to science are globally recognized in literature (Lee and Pollitzer, 2016). Yet, across the world, women remain underrepresented in science (Elsevier, 2017), and UNESCO reports that in 2015, only 28% of researchers around the globe were women (Huyer 2015). Beyond the numerical imbalances, there is a large disparity between men and women in terms of publication outputs. A study of 5.5 million papers and 27.3 million authorships found that men produce 70% of papers and hold two-thirds of first authorships (West *et al.*, 2013). Other large scale studies find similar patterns (Bornmann, Bauer and Haunschild, 2015). Gender equality in the context of science clearly remains a global concern.

This gender agenda in science is of particular relevance in Africa, specifically in the context of agricultural research and development. The need for female leadership in science and agriculture is of particular interest in Africa given the pivotal nature of the sector in the social and economic development of the continent. Furthermore, agriculture has an important role to play in achieving

the global development agenda articulated in the Sustainable Development Goals. Agriculture as a sector contributes either directly or indirectly to no fewer than nine of the 17 goals (Farming First, 2015), and while female farmers are a vital force in Africa's agriculture, agricultural research and higher education are disproportionately led by men. Women comprise on average 43 percent of the agricultural labor force in developing countries, and over 50 percent in parts of Africa (FAO, 2017). Yet only one in four agricultural researchers are female and even fewer – one in seven – of the leadership positions in African agricultural research institutions are held by women (Beintema and Di Marcantonio, 2010). Thus, while African women labor in fields across the continent, they remain underrepresented in leadership positions where priorities for agricultural research are set, resources are allocated, and policy decisions are made.

This paper focuses on evaluating a science skills capacity building program developed by the African Women in Agricultural Research and Development's (AWARD) aimed at improving the science skills of women scientists, thereby empowering them to advance to, and be retained in, leadership positions in agriculture.

Literature review

At the highest level, the African Union's Agenda 2063 recognizes not only the importance of agriculture, but the central role that women will play in Africa's agricultural transformation agenda as producers, researchers, and policy-makers (AU, 2013). Similar sentiments are echoed by important continental role players, including the African Development Bank (AfDB, 2016).

According to the United Nations Economic Commission for Africa and Food and Agriculture Organization, gender-sensitive production interventions coupled with equal access to productive resources for women farmers can lead to yield increases between 20–30 percent (FAO, 2011; Njobe and Kaaria, 2015). The United Nations estimates that if women farmers had the same access to resources as men, the number of hungry in the world could be reduced by up to 150 million (SDG Fact Sheet, 2015). Not surprisingly, the World Bank Gender Action Plan (Zuckerman, 2007) termed investments in women and gender equality as “smart economics” and, together with the One Campaign, the World Bank (2014) called upon African governments to focus on closing the gender gap and to provide farmers, particularly women, with better access to agricultural knowledge and information that answers their needs (Zuckerman, 2007; O'Sullivan *et al.*, 2014).

To see these efficiencies in production, it will be necessary to ensure that women participate appropriately in agricultural research and development. Research shows that innovation is optimal when women and men scientists work together in teams with at least a 50:50 gender mix (Gratton *et al.*, 2007). Further, it is confirmed that the diversity brought about by this gender mix leads to better performance in innovation; gender diverse teams outperform the non-diverse ones on innovation, problem-solving, flexibility, and decision-making (King, 2005). Recognizing this potential, authors (for example Meinzen-Dick *et al.* (2011)) called for increasing the number of women employed in national, regional, and international research institutes and providing them with the incentives and structures they need to succeed.

More recently, the International Food Policy Research Institute (IFPRI, 2014) and the International Fund for Agriculture Development called for seeking women's diverse points of view to encourage innovation, policy change, and sustainable food production for balanced

nutrition (Chakrabarti, 2014). To achieve this, Beintema and Di Marcantonio (2010) note that strengthening Africa's agricultural research capacity requires not just more women participating in absolute terms, but that they do so in senior, decision-making roles.

For all of the above reasons, to be fully effective, agricultural projects and programs targeted at increasing agricultural outputs and incomes, as well as food and nutrition security, need to incorporate gendered dimensions recognizing the diverse roles of men and women agricultural value chain actors (World Bank, FAO and IFAD, 2009).

How do we ensure that women's potential is fully realised?

Research shows that career women face similar career advancement challenges across geographies and industries, which must be addressed at individual, institutional, and systemic levels (Schipani *et al.*, 2008; Carter and Silva, 2010; Hoobler, Lemmon and Wayne, 2014). Career advancement in any field is pegged on technical competence and, in the case of women scientists, support to overcome barriers to the building up of their science skills, as well as their networks and access to opportunities (Meinzen-Dick *et al.*, 2011).

Various programs support postgraduate training in agricultural disciplines across Africa and attempt to attract an equal number of women and men. The Alliance for a Green Revolution in Africa and the Regional Universities Forum for Capacity Building in Agriculture are just two examples. These are important and needed initiatives. However, to retain the skills and advance the careers of female scientists, academic training and bursary support alone is insufficient, and a gender specific approach is imperative as many women leave the field of research for reasons that are gender specific. Women in science face various challenges, including lower salaries, fewer professional networks, limited access to mentors and limited opportunities for promotion. Women also have fewer role models within their institutions (Hewlett *et al.*, 2008; Hewlett *et al.*, 2014; Hunt, J, 2010). Capacity strengthening must therefore take a more holistic approach to empowerment through a comprehensive science skills capacity-building initiative. A comprehensive intervention of this nature should tackle a broad range of issues and include lack of know-how on raising financial and technical resources for innovative research projects; lack of adequate access to cutting edge information on agricultural research and development trends; lack of professional visibility due to not publishing in scientific journals or attending industry conferences; and lack of insights on the importance of gender-responsiveness in agricultural research and development.

Designing a holistic science skills capacity-building initiative

In 2006, the Gender and Diversity Program of Consultative Group on International Agricultural Research (CGIAR) ran pilot capacity building programs in several of its centers around the world, with one focused on crop science researchers in East Africa. From the East African pilot, Gender and Diversity gleaned that African women scientists are empowered through the combination of mentoring, leadership development, and sound science skills, as well as increased visibility (CGIAR, 2006).

This informed the overall design of the AWARD fellowship program as a holistic and robust professional development program for African women scientists. Since 2008, AWARD, through

tailored fellowships, has equipped top women agricultural scientists across sub-Saharan Africa to accelerate agricultural gains by strengthening their science and leadership skills. The details of the program are discussed in Noordeloos (2015). Approximately 70 fellows are accepted on an annual basis. The fellowship is built on three components – mentoring, science skills development, and leadership skills development. Fellows benefit from being matched with a mentor (a respected male or female senior scientist in her area of expertise) and are offered a range of courses designed to improve their ability to share their knowledge, through science and proposal writing courses, and to improve their presentation skills.

In this paper, we describe and evaluate the effectiveness of the science component of the program in building up the science skills of leading African women scientists in research excellence, gender-responsiveness in agricultural research and development, scientific presentation skills and fundraising for agricultural research and development projects. A description of the rationale and focus of the science component is provided, followed by the results of the evaluation from the 2013 and 2014 cohorts.

Evaluating within an empowerment framework

AWARD's African Women in Science Empowerment framework, which is directly linked to the program's theory of change, identified five types of empowerment needed for female agricultural researchers. The five types of empowerment are referred to as "powers", each of which is illustrated in Table 1.

To address the identified science capacity challenges among women scientists and to contribute to building a healthy talent pipeline in African agricultural research and development, the program set up the science component which is a comprehensive portfolio of diverse but interconnected courses and approaches aimed at building the technical capabilities of women scientists in scientific research, networking, and fundraising, as well as incorporating gender dimensions in agricultural research and development. The science component is embedded in the empowerment framework (Table 1), and falls under the research and fundraising dimension of "Power to Do". The science component lies at the center of the fellowship. Through participation in this component of the fellowship, fellows gain by having enhanced capabilities to achieve professional autonomy through increased access to information and knowledge, contacts, networks and opportunities, as well as improved scientific skills in publishing, presenting, fundraising, conducting gender-responsive research, and undertaking scientific research. All these components contribute to increasing the quality of research and agricultural research and development outputs from these women scientists and their institutions, thereby raising the visibility of both as sources of innovations.

Science interventions complement leadership development and mentoring to form a holistic package of empowerment experiences that together are expected to elicit higher outcomes.

Table 1: AWARD's African women in science empowerment framework

Powers	Power sub-domains
Power from Within	<ul style="list-style-type: none"> • Self-confidence • Self-knowledge • Motivation • Vision and direction
Power to Do	<p>Access to</p> <ul style="list-style-type: none"> • Knowledge and information • Opportunities • Contacts and networks <p>Leadership capacities</p> <ul style="list-style-type: none"> • Present oneself professionally • Manage diversity • Leverage team talents • Formally mentor others • Negotiate • Network <p>Scientific capacities</p> <ul style="list-style-type: none"> • To conduct research • To conduct gender-responsive research • To fundraise • To present (work or research)
Power Over	<ul style="list-style-type: none"> • Career Progress, including promotions and education achievements • Visibility • Professional Recognition, including professional awards, invitations and additional bursaries/fellowships
Power With	<ul style="list-style-type: none"> • Participating in collaborative activities • Leading collaborative activities
Power to Empower	<ul style="list-style-type: none"> • Efforts to raise awareness of gender responsive research & development • Strengthen capacities around gender responsive research & development • Influence on norms, policies and strategies for gender responsive research & development

The science component

The fellowship expands the world of science for its fellows by facilitating their access to the latest methodologies and technologies and building their professional networks. In turn, it brings the groundbreaking work of African women in agricultural science to the national, regional, and global stages, where it is much needed. More specifically, the science component consists of: paying a fellow's membership in a professional association for two years; providing support to

attend a science conference; participating in a science skills course, with an introductory session followed by a choice between science writing or proposal writing; and the opportunity to apply for advanced science training, with fellows chosen through a competitive process (open to fellows who have already attained masters' and/or doctoral degrees).

Professional association membership

Our data shows that African women scientists, particularly those with a bachelor's degree, are not commonly members of international science societies or professional associations. This trend is not unique to Africa; the *Gender in the Global Research Landscape* report (Elsevier, 2017) found that women are less internationally networked than their male peers in science. As one of the pathways to improve networks and international connections, fellows get the opportunity to connect with the latest debates, methods, and findings relevant to their research by the fellowship paying up to US\$100 for a two-year membership in a professional association of the fellow's choice. These memberships are intended to help fellows increase their professional networks, visibility, access to cutting-edge scientific knowledge, and to information about conferences and job opportunities.

Science skills courses

The science skills course offers fellows a general introduction into an array of scientific and communications issues ranging from research methodologies, grant proposal writing, scientific writing, and presentation skills. After the introductory session, which all fellows attend, the focus shifts to communication and the fellows can choose whether to focus on either proposal or science writing. Table 2 shows the main distinctions between the two writing courses.

Table 2: AWARD science courses

Research Proposal Writing	Science Writing
The core training of this course grounds participants in the skills required for effective research proposal writing in order to raise funds from different donors. These include the steps in developing a research proposal from a concept note and writing with clarity and purpose.	The course addresses the importance of publishing research findings to attract funding and the relevance of establishing a personal scientific track record. Publishing in science journals opens up opportunities for promotion at work, as well as knowledge sharing with peers.

Source: AWARD

In addition to providing insight into different forms of scientific writing, including policy briefs, the course offers hands-on use of the Access to Global Online Research in Agriculture (AGORA) program. This program, set up by the Food and Agriculture Organization (FAO) together with major publishers, facilitates developing countries to access an outstanding digital library collection in the fields of food, agriculture, environmental science, and related social sciences. This improves competence and introduces basic skills in gender-responsive research

and gender-disaggregated data collection and analysis. As a result, fellows gain confidence through working in a different environment, improve their presentation skills and personal branding, and increase their understanding of ethical issues in research.

Advanced science training

Advanced science training is an instrumental component of the program that helps fellows build solid scientific skills and knowledge in their areas of expertise. These are the skills and knowledge needed for producing the technological innovations and advances that contribute to positive, sustainable impacts in agricultural research and development. Fellows are carefully selected to ensure that there is close alignment among the advanced science training course's focus and their career goals, home institution research priorities, as well as the host institution's mandate and research focus.

Advanced science training can take the form of a research attachment to a state-of-the-art institution for three to nine months where fellows conduct research under the supervision of highly experienced and seasoned scientists. The importance of international placements in establishing long-term research partnerships is well-acknowledged (Elsevier, 2017), and globally the lack of international networks has been noted as one of the factors which limit women's rise to leadership in science. The advanced science training thus contributes directly to science skills development, but also enables fellows to establish important networks.

Alternatively, the advanced science training can be a technical short course of one to three weeks in areas such as gender-responsiveness or other science subjects. The short-course option was added in 2010 because the program recognized the need to accommodate fellows who are unable to get away for the longer courses due to family or work responsibilities, or visa restrictions.

Methodology

Organizing questions

Data was collected through the program's internal monitoring system and questions were aligned to the theory of change and the empowerment framework. Structured questions were used to determine to what degree (if at all), the program contributes to the changes in science capacity that the fellows experience.

The following outcomes were assessed as the most directly related to the science component:

- Improved overall research capacities – ability to conduct research, to publish, as well as to produce technologies, develop methods and generate intellectual property.
- Improved capacity to conduct gender responsive research– ability to conduct research in a gender responsive way.
- Fundraising capacity – ability to raise funds for research and/ or projects.
- Presentation skills – ability to present research, ideas and information clearly and effectively to a relevant audience.

Data sources

The findings discussed in this article are based on data collected from the 2013 and 2014 cohorts of fellows. The data were collected from fellows by an independent contractor through the distribution of final evaluation forms at the end of the two-year fellowship, via the survey software program QuestionPro. The software allowed for the online completion of the evaluation forms by the fellows, and allowed the data to be directly downloaded from the online platform, ensuring data quality and integrity. To make triangulation between multiple datasets possible, data collection was not anonymous, although all data were treated with the strictest confidence. Specifically, data discussed were collected from the 2013 and 2014 cohorts, comprising a total of 139 fellows. An average response rate of 88 percent (122 fellows) was obtained.

Assessing change and programmatic contribution to change

In order to assess change in the outcomes, as well as the program's contribution to these changes, fellows were asked to complete an evaluation questionnaire consisting of quantitative and qualitative questions measuring each of the outcomes. Quantitative questions measuring change used a retrospective baseline approach and asked fellows to rate themselves on each outcome at the start and at the end of the fellowship, using a five-point Likert scale ranging from "very low" to "very high".

This approach allowed for individual level change to be calculated for each fellow on each of the outcomes. Verification of the change reported was achieved through requesting fellows to provide full details on peer-reviewed publications they contributed to, their conference participation, and successful fundraising endeavors they engaged in, during the fellowship period.

While quantitative questions asked fellows to rate themselves before and after the fellowship on each of the outcomes in question, qualitative questions were presented to fellows after the series of quantitative questions, and did not prompt fellows to describe changes with respect to all outcomes. Rather, fellows were asked to report on the most important changes they have experienced and to provide concrete examples illustrating these changes. In addition, a single quantitative question allowed for the strength of the program's contribution to the changes to be identified, as illustrated in Box 1.

Box 1: Example of a quantitative question

To what extent was the AWARD Fellowship a factor in bringing about any changes to your inner power?

- I did not experience any changes to my 'research and fundraising capacities
- Negative factor
- No factor
- Minor positive factor
- Moderate positive factor
- Major positive factor

Source: Fellow Evaluation Form

A single follow-up qualitative question asked fellows to reflect on the role the program played in bringing about the changes. Fellows were asked to identify specific activities and to explain how these activities enabled or contributed to the changes they experienced.

Data analysis

Quantitative data analysis

Quantitative data were analyzed using the Statistical Package for the Social Sciences (SPSS). Data transformations were carried out to compare fellows' *start* and *end* of fellowship assessments of their progress made on each of the outcomes. Based on these data transformations, the number of fellows who experienced change on an outcome could be determined and the scale of change identified. Further transformation was carried out to create a single variable determining the total number of outcomes where change was reported by each fellow.

Descriptive statistics in the form of a frequency table were run on this final transformed variable to determine the number of fellows who showed change on all outcomes. A frequency table was also run for the quantitative question on the program's contribution to change, providing a summary of fellows' ratings of this contribution to the development of their science capacities.

Qualitative data analysis

Deductive qualitative coding was done using Dedoose, an online mixed-methods data analysis tool. Qualitative stories of change in the research and funding dimension were deductively coded and rated in terms of their credibility as either lackluster, convincing, or compelling. Fellows who have credible evidence in their descriptive stories were considered to have qualitative evidence of change for that particular outcome and were included in the integrated mixed-methods analysis. Fellows with lackluster evidence of change were considered to have no evidence of change.

Detailed code descriptions were agreed upon to improve consistency in the coding process. Data were coded by a small team of researchers, all of whom have been engaged with the program for at least three to five years. Resource constraints limited the extent to which all coded excerpts could be verified by a second researcher. However, 10-15 percent of excerpts were selected for verification. The combination of convincing and compelling stories was counted as credible evidence.

Fellows were asked to reflect on the program's contribution to the change they experienced. Fellows were also asked to reflect specifically on how the program facilitated change through describing activities or processes in the fellowship. Qualitative coded responses were counted to identify the activities which make the strongest contribution to change. Finally, using the Dedoose mixed-methods analysis tools, code application data at the individual fellow level was exported from Dedoose to Microsoft Excel integration with the quantitative data.

Triangulating change and programmatic contribution to change

Triangulated change for science capacity was determined by matching a fellow's quantitative change to their qualitative stories. Change was considered triangulated if quantitative change and a credible story were both found for an individual fellow. All fellows who showed triangulated change on at least one outcome were counted as having "*triangulated evidence of change*", and all fellows who did not show triangulated change on any of the outcomes as having "*no triangulated evidence of change*".

A similar approach was taken when triangulating the program's contribution to change. Quantitative and qualitative responses were triangulated to verify the strength of the program's contribution. If a fellow indicated that the program had played a role in their quantitative response and had written a feasible narrative in their qualitative response, that contribution to change was considered verified.

Results

Scientific outcomes

As discussed in the methodology, fellows were asked to report changes in their capacities related to their capacity to conduct research, to conduct gender responsive research, to fundraise for research, to present research findings, in *qualitative and quantitative* questions.

Figure 1 illustrates the number quantitative changes fellows reported. The majority of fellows (86 percent) reported quantitative changes in all four of the science outcomes.

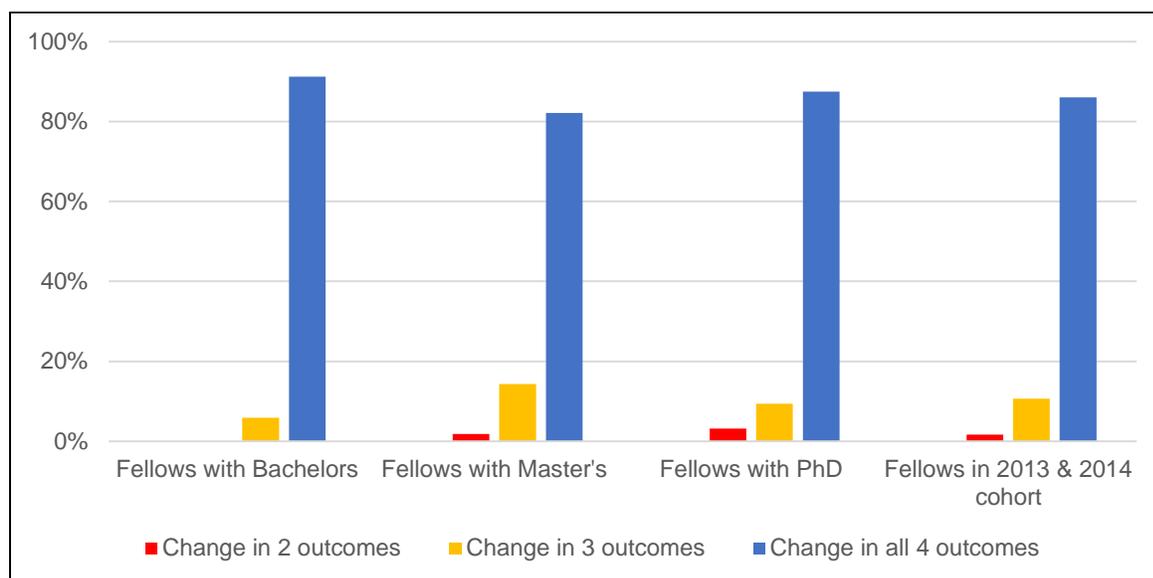


Figure 1: Percentage of fellows with quantitative evidence of change on the science outcomes

The changes across these outcomes is confirmed by the qualitative data. Qualitative data (illustrated in Figure 2) showed that half of the fellows had credible evidence to support the changes they experienced related to their capacity to conduct research and their capacity to present their research. Forty percent had credible qualitative evidence to support the changes they experienced with regards to their capacity to raise funds for the research; and a third of fellows shared credible stories relating to their increased capacity to conduct gender responsive research. Given that the qualitative questions did not prompt fellows to describe changes with respect to all outcomes, but rather were asked to report on the most important changes they have experienced, this distribution of qualitative evidence supports that fact that the design of the science component to address a range of science outcomes was an appropriate choice.

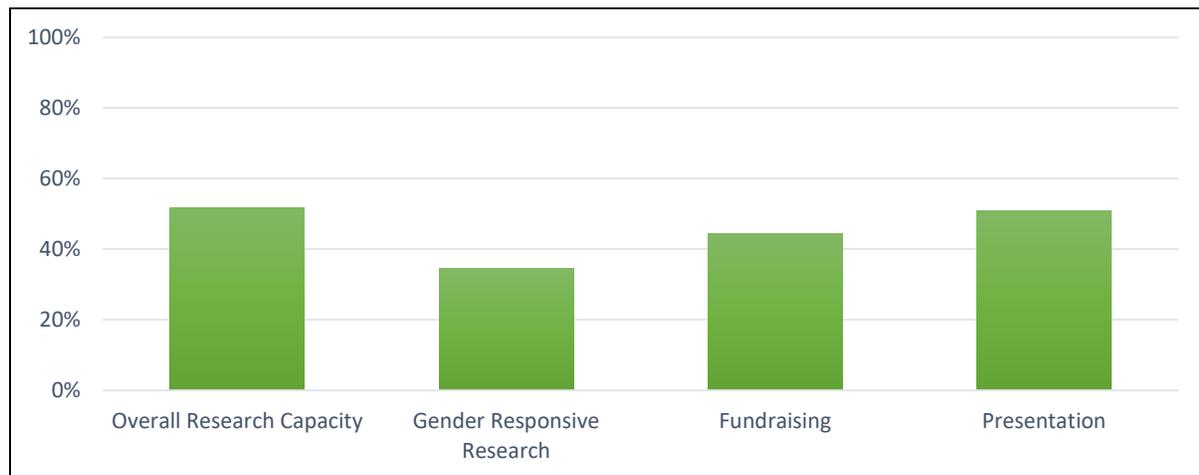


Figure 2: Percentage of fellows with qualitative evidence of change on the research and fundraising outcomes

Triangulated results, combining quantitative evidence of change with credible qualitative stories showed that the vast majority of fellows (87 percent) had triangulated evidence for change in their science capacity. There was no difference in the triangulated data between fellows who have different levels of qualification, suggesting that regardless of qualification the bouquet of offerings (courses, conference sponsorship, advanced science training and professional association membership) work together to develop science capacity for fellows. This assertion is supported by the qualitative data which identified science courses, conference participation and advanced science training as the three most important (out of a total of 14) fellowship activities for developing science capacity.

Each of the four specific outcomes are discussed in greater detail below.

Capacity to conduct research

There was a clear shift in capacity to conduct research from before to after the fellowship based on quantitative ratings. Only eight percent of fellows reported high levels of research capacity at the start of the fellowship, whilst 87 percent indicated that they had high to very high levels of

research capacity after the fellowship period. These very low ratings of capacity at the start of the fellowship confirm the need for research capacity development initiatives among women regardless of their level of qualification.

An analysis of science outputs in the form of publications was done to illustrate the expression of fellows' research capacities. Seven out of every 10 fellows had contributed to at least one publication during the fellowship period – including peer-reviewed journals, conference proceedings, technical reports, and books/ book chapters. The rate of publication (shown in Table 3) was expectedly different between fellows with a bachelor's degree (44 percent had published) and those with a PhD (84 percent had published).

Table 3: Fellows' publications

	Total number of publications	Number and percentage of fellows publishing	
		Total	Percentage
pB	61	15	44%
pM	209	43	77%
pD	219	27	84%
All Fellows	489	85	70%

The publication outputs by type of publication are summarized in Figure 3. A total of 58 percent of fellows had contributed to peer-reviewed publications.

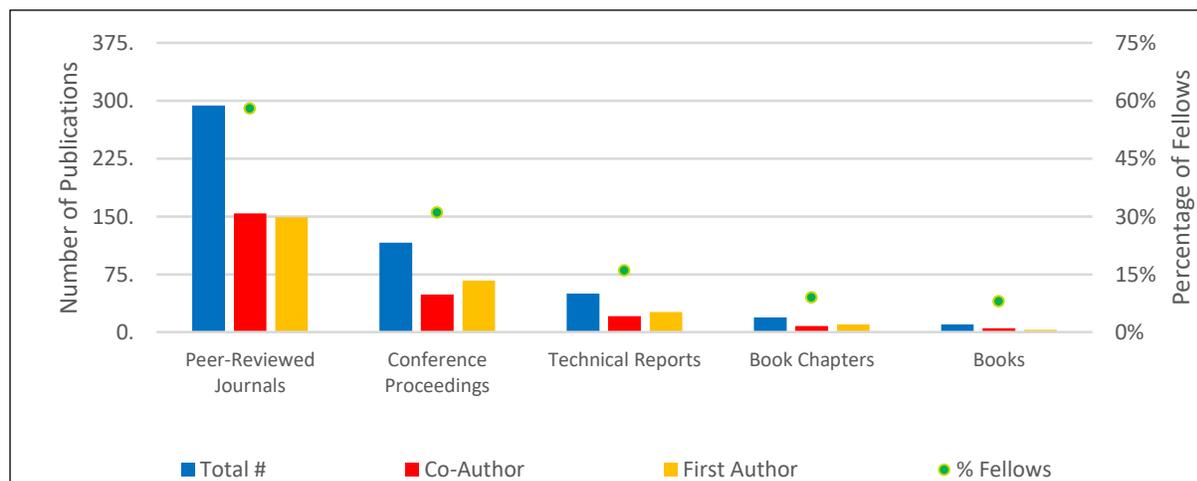


Figure 3: Number of publications by type and authorship

The absence of data related to typical publication rates in African agricultural research limits the extent to which direct comparisons to the productivity of female scientists can be made.

However, an interesting finding is that the fellows contributed to relatively equal numbers of first authored and co-authored papers, yet globally men hold two-thirds of first authorships (West *et al.*, 2013).

Figure 4 illustrates in further detail the number of peer-reviewed journal publications, disaggregated by level of qualification. Again, as would be expected, fellows with a PhD produced the highest number of peer-reviewed publications. For each level of qualification, the average number of publications and the average number of publications per publishing fellow, is shown. The average number of publications per publishing fellow was 2.80 for fellows with a bachelor's degree, 3.38 for fellows with a master's degree and 5.88 for fellows with a PhD. Again, data to make direct comparisons is lacking, yet the results of other global studies indicate that these achievements may indeed be very impressive. For example, Ioannidis, Boyack and Klavans (2014) found that less than 1 percent of the world's scientists manage to publish on an annual basis – an average that is far outperformed by the group of fellows.

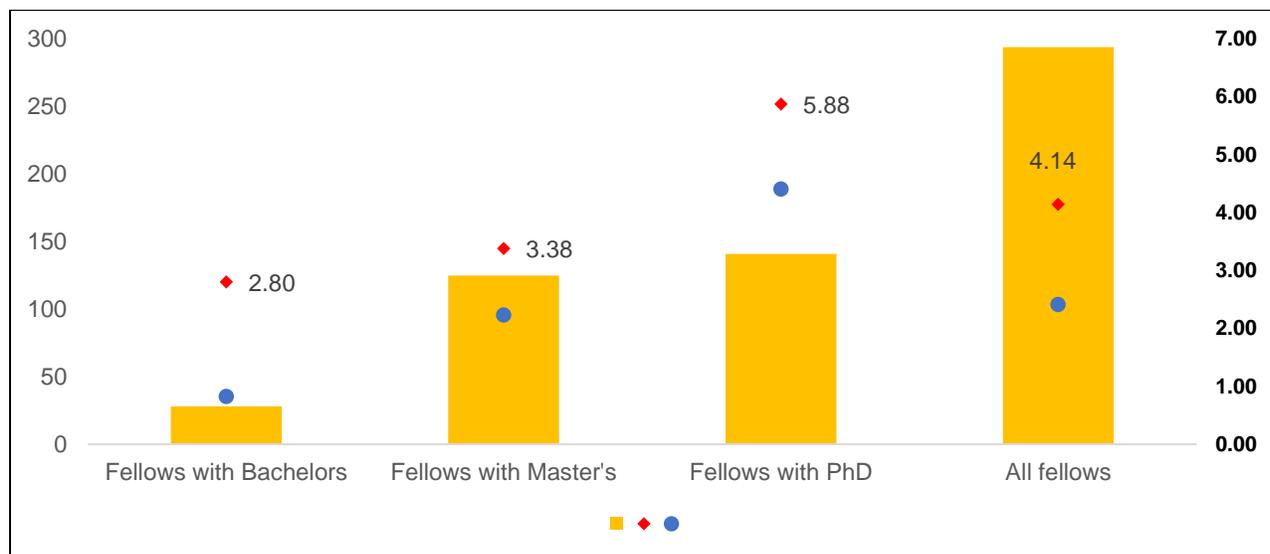


Figure 4: Rate of publication in peer-reviewed journals by level of education

Apart from the quantitative evidence for enhanced science capacity, fellows' qualitative stories illustrate aspects of the changes that are most salient and meaningful to them. For their overall research capacity, 52 percent of fellows provided stories deemed as credible qualitative evidence of change in their research capacity (illustrated in Figure 2), for example:

My capacity to do research has increased during AWARD fellowship I have manage to for the first time to publish two papers in an international journal as first author.
(2014 cohort, fellow with PhD, questionnaire/feedback form, 2015)

Capacity to conduct gender responsive research

Based on quantitative ratings, only two percent of fellows had “high” levels of capacity to

conduct gender responsive research at the start of the fellowship. This shifted to 80 percent, indicating they had “high” to “very high” levels of capacity after the fellowship period. Almost all fellows (98 percent) indicated changes in this aspect of their capacity during the fellowship period.

In addition to the quantitative evidence, 34 percent of fellows also provided qualitative evidence of change in the form of credible stories of how their capacity to conduct gender responsive research improved, for example:

After the field visits to village in Uganda to learn about Gender responsiveness and analysis, I changed my scientific methodology by first understanding what the community wanted, unlike the top-down science I used to do. I also learnt how to go back to the community and give feedback. The gender analysis tool taught to us made it possible to work with vulnerable and marginalized communities who are illiterate.
(2013 cohort, fellow with PhD, questionnaire/feedback form, 2016)

In my opinion, AWARD was not exactly a program to my move research capacities to significantly different levels especially since I had previously been engaged in intense research work. However, I am glad to note that AWARD allowed me to look at gender seriously when writing proposals. AWARD gave me an opportunity to hear real life experiences on how young scientists are doing fundraising and gave me the morale even to write proposals of this nature myself.
(2014 cohort, fellow with master’s degree, questionnaire/feedback form, 2015)

The subtleties in these stories illustrate the different ways in which the program facilitates different changes for different fellows. Where one fellow may not need research skills strengthening, the tailored nature of the fellowships is flexible enough to provide support in another way, for example through the motivation and insight needed to write proposals for gender responsive research. This finding further affirms the decision of the program to focus on a range of outcomes and a variety of fellowship activities designed to meet the diverse needs of women scientists.

Capacity to raise funds for research

Based on quantitative ratings, only one percent of fellows had “high” levels of fundraising capacity at the start of the fellowship. This shifted to 63 percent, indicating they had “high” to “very high” levels after the fellowship period. Nine out of 10 fellows indicated changes in this regard.

Table 4 illustrates the *number of fellows*, by level, who successfully obtained funding for research. Although 49 percent of fellows had been successful in obtaining funding for research, fellows with doctoral degrees (72 percent) were more successful in this regard. This finding was expected given both their level of experience and their seniority in research teams.

Table 4: Successful fundraising by level of qualification

	# fellows with successful proposals	# Successful funding proposals	# Limited Contributor	# Significant Contributor	# Lead Contributor
pB	13 (38%)	18	0	8	9
pM	24 (43%)	42	4	17	21
pD	23 (72%)	60	8	32	26
All fellows	60 (49%)	120	12	57	56

Table 4 illustrates the total number of successful research funding proposals disaggregated by level of qualification, as well as the number of proposals where fellows were limited, significant, or lead contributors to the proposal. Fellows with doctoral degrees were the most successful, with 60 successful research funding proposals. In total, there were 120 successful research funding proposals, 12 of which fellows made limited contributions to, 57 where fellows were significant contributors and 56 where fellows were lead contributors. The high proportion of proposals where fellows are lead or significant contributors is particularly significant in light of the gender disparities observed globally in terms of funding success. Lack of research funding has been cited as one of the factors constraining women from rising to the highest level in sciences (Widmer, 2008), and the high level of success among the group of fellows is a positive finding.

Apart from the quantitative evidence, 44 percent of fellows (illustrated in Figure 2) also presented credible evidence of change in their qualitative narratives clearly showing change in their fundraising capacities, for example:

Prior to joining AWARD, I had limited networks and would hardly get noticed by people in my field of Soil Science but after AWARD I got linked up to other Soil Scientists. For example one of the other fellows works with University of Zambia and is a Soil Scientist and through her link with a former Malawian AWARD fellow, she connected with me and we wrote a proposal to APPSA and got funding to carry out a research using Biochar. This would not have taken place without AWARD networks (2014 cohort, fellow with a master's degree, questionnaire/feedback form, 2015)

AWARD served as an eye opener to my inbuilt capabilities. At my second year in AWARD, I was able to write a proposal that pulled a sum of \$7,500 for a gender responsive research in my locality from my institution. (2014 cohort, post-master's fellow, questionnaire/feedback form, 2016)

Capacity to present research findings

Based on quantitative ratings, 14 percent of fellows had high levels of presentation capacity at the start of the fellowship. This shifted to 96 percent indicating that they had “high” to “very high” levels after the fellowship period. More than 95 percent of fellows indicated a shift in their ability to present their research during the fellowship period.

In addition to the quantitative evidence, 51 percent of fellows (illustrated in Figure 2) provided stories deemed as credible qualitative evidence of change in their capacity to present research findings, for example:

Presentation capacity was enhanced through coaching and practicing. I felt very confident presenting at the International Conference for Mushroom Biology and Mushroom Products in India because I already knew how to make a good presentation (how to prepare a good presentation and how to present the same to an audience). I no longer panic like I used to before and I am very grateful.
(2013 cohort, post-bachelor’s fellow, questionnaire/feedback form, 2015)

Program contribution to changes

Fellows were asked to reflect on the program’s contribution to the change they experienced in their science capacity through qualitative and quantitative questions, as discussed in the methodology section. Figure 5 illustrates triangulated responses on the programs contribution to the growth of the science outcomes. The program played an important role in facilitating changes for fellows in terms of their overall research, gender responsive research, fundraising, and presentation skills, with triangulated evidence for a strong verified role reported by 93 percent of fellows.



Figure 5: Strength of program’s contribution to changes

Conclusion

As noted by the International Food Policy Research Institute (IFPRI, 2014) and Chakrabarti (2014), the diverse points of view of women in agricultural research are needed to encourage innovation, policy change, and sustainable food production for balanced nutrition. Increased participation of female scientists in agriculture may drive gender-sensitive production interventions and equal access to productive resources for women farmers, leading to the 20 to 30 percent yield increases (predicted by the Food and Agriculture Organization (FAO, 2011)). However, merely increasing the absolute number of women in agricultural research is not enough. Both career advancement and retention are crucial for women in agriculture, since strengthening Africa's agricultural research capacity requires participation from women appointed in senior, decision-making roles (Beintema and Di Marcantonio, 2010).

The foundation for achieving this representation and retention is a pool of highly skilled female scientists who have the range of capacities needed to succeed in science careers – which include, but are not limited to – the capacity to conduct cutting-edge research. Career advancement is strongly related to technical competence (Meinzen-Dick *et al.*, 2011), making the successful implementation of capacity building programs such as the one reported here, crucial. The science component of the program was designed to contribute directly to this pool by enhancing the science capacities of its fellows through a nuanced two-year fellowship.

From the perspective of technical competence, the study found that the program has contributed strongly to the capacity of the female scientists to conduct research. Although no directly comparable data is readily available, based on global publication trends the fellows demonstrated impressive levels of publication during the fellowship period, as well a highly positive proportion of first authored publications. The contribution to research capacity was the most salient change experienced by fellows. Further research is however required, for example, an in-depth bibliometric study would provide insight into issues such as the quality of papers produced and patterns of publication collaboration.

While more than 90 percent of fellows improved their capacity to raise funds, far fewer fellows rated themselves as highly competent on this outcome at the end of the program. The most likely reason for this is the complex nature of fundraising proposal writing, and the limited exposure scientists get to this during their academic training. Thus, for many, the proposal writing course is one of the first times they get direct input and guidance on how to approach fundraising. The importance of funding for research in career advancement and retention (Wider, 2008) (and the gender disparity in success rates) provides a strong rationale for the inclusion of proposal writing skills courses in science capacity strengthening programs for women.

The success of the program shows the importance of incorporating gender dimensions into capacity building programs. Although overall research capacities showed the greatest shifts, notable positive changes also took place in the women's capacities to conduct gender-responsive research. Follow-up studies of a bibliometric nature could yield interesting results in the future by tracking shifts in the proportion of research fellows publish that take gender into account. This will be the true test of the sustainability of the impact the program had on its fellows.

The positive shifts reported by the fellows, and the strong linkages drawn to the various program components confirm the success of and need for programs of a similar nature to set the foundation for women in agricultural sciences to succeed. Several key lessons can be drawn from

the program experiences that have application for similar initiatives. These include the benefit of

- focusing on the development of multiple skills (for example the combination of research and fundraising skills);
- offering a range of activities which can contribute synergistically to capacity development (for example advance science training contributed to the production of high quality science, whilst conferences offer the opportunity to present science);
- tailoring programs to meet the needs of participants and allowing the element of choice (for example, fellows could choose either a science writing or a proposal writing course, dependent on their perceived need);
- consistently monitoring and evaluating the effectiveness of the offerings and remaining responsive to feedback (for example the program changed its options for advanced science training after feedback showed that many women could not travel for extended periods of time).

Further research is however required to examine the impacts of the program on the longer-term career progress of fellows, to determine whether they are retained in the system and advance to high level positions of influence. The recent completion of the fellowship for these cohorts (2015 and 2016 respectively) meant that retention and career progress could not yet be measured, but the programs strong alumni network provides a platform for longitudinal tracking of fellows in years to come.

The evaluation of the program has found notable successes, and similar initiatives are needed to bolster the corps of highly skilled female scientists. However, whilst this is a strong foundation, it is not a fix-all solution. Programs to bolster capacity set women up for success, but of course cannot guarantee it. Women scientists need to work and function in enabling institutional environments that have made the necessary commitments and taken the necessary actions to be gender responsive. Ultimately it is the combination of individual capacity and institutional conditions that will lead to women reaching their full potential to bring about optimal innovation, problem-solving, flexibility and decision-making in agricultural research and development (King, 2005; Gratton *et al.*, 2007). There is much work that still needs to be done from an institutional perspective in African agricultural research and development, and program designers are encouraged to think about how individual and institutional capacities can be simultaneously strengthened with regards to gender responsive science.

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