Research capacity for neglected and underutilized species: a situation analysis in ten African countries

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Abstract

Hundreds of traditional minor crops exist in Africa which are highly nutritional and often well adapted to local environments, such as marginal soils and drylands, but their broader use, e.g. for food security and in climate change adaptation is constrained by weak scientific capacity to work on such crops. Between 2010 and 2012 more than 1300 young African scientists applied to seven training courses on neglected and underutilized species (NUS) that targeted ten countries in West and Southern/East Africa. The high demand raised questions about the availability and quality of capacity development in this field, what NUS research is currently taking place, and the main constraints NUS researchers face. To investigate these questions, a survey was administered by email to the scientists who had applied to the training courses. The survey had 383 respondents between 24 and 57 years of age. The majority held a Master's (61%) or PhD (31%) in agriculture or a related field. Most respondents were involved in NUS research at the time of the survey, or wanted to research NUS in the future. A broad range of NUS crops and trees were being studied in their research, including legumes and pulses, cereals, leafy vegetables, fruits, nuts, roots and tubers. The main issue addressed was nutrition, followed by characterizing and conserving genetic diversity, and aspects of NUS production and marketing. Funding was the most frequent constraint to NUS research. Poor quality of facilities and lack of information were other limitations. External support for NUS research, including policy support, was uneven; about half ranked it as poor or non-existent while one tenth found such support very good or excellent. Overall, this survey reveals a strong interest in, and skills base for NUS research among African scientists. Increased opportunities for training, networking, and funding would strengthen this emerging and important field of research. These results could guide decision makers regarding strategies and action plans for developing capacity for NUS research, development and education with the aim of diversifying agriculture sustainably.

Key words: Capacity development, training, mentoring, neglected and underutilized species, research methods and themes, West Africa, Eastern/Southern Africa, expert survey

Introduction

Green Revolution technologies and farming practices have led to dramatic yield increases in many parts of the world. In sub-Saharan Africa, however, yield increases have been more modest; the increase in production has been mainly due to expansion of the area cultivated (Evenson and Gollin, 2003; Tadele and Assefa, 2012; Otsuka and Larson, 2013). The failure of the Green Revolution in Africa has been attributed, among other factors, to variable and harsh environmental conditions, and inconsistent access to inputs, labour and markets. Without the yield rewards of Green Revolution practices, Africa has still suffered many of the consequences of simplified, intensive production systems, including an impoverished dietary diversity. This is linked to a breakdown of traditional food systems and a shift towards Western-type cereal-based, energy-rich diets, which also leads to increases in diet-related non-communicable diseases (Frison et al., 2005).

Hundreds of minor crops have historically been valued in traditional cuisine and cultures across Africa and remain an important food source for the rural poor today. These crops are often well adapted to local environments, such as marginal soils and drylands, and they provide many vital macro- and micro-nutrients that enhance human well being (Padulosi et al., 2013). These neglected and underutilized species (NUS) of crops and trees have great potential to improve nutrition, livelihoods, and the sustainability of farming systems in sub-Saharan Africa but they have not received adequate investment by research and development efforts, which have tended instead to promote displacement of indigenous crops with major staples and commodity crops (Frison et al., 2005; Padulosi et al., 2013).

In many cases, social attitudes have also shifted away from traditional foods as they are considered 'poor-man's crops' or are no longer accessible or convenient for rapidly urbanizing populations. NUS crops are also statistically neglected; national food supply data both generalize (e.g. lumping together several species) and underestimate food crop diversity (focusing mostly on major food crops), and FAO data lack the resolution necessary for tracking trends in geographically restricted food species (Khoury et al., 2014). Awareness is growing in Africa and elsewhere, however, regarding the importance of diversifying agricultural production (FAO, 2011) to address hunger, poverty and climate change adaptation and it is recognized that NUS are key assets in these pursuits (Tadele and Assefa, 2012; Chivenge et al., 2015).

Enhancing the cultivation and use of NUS in Africa requires a strong research and development effort that crosses disciplines and includes all value chain stakeholders from seeds to final use. Farmers are central stakeholders in these efforts due to their roles as producers – and managers of NUS genetic resources – and also often as traders and consumers. Their participation helps identify constraints in the value chains and priorities for upgrading. In turn, improving farmers' links to markets provides economic incentives for on-farm conservation of these marginalized resources (Garcia-Yi, 2014; Padulosi et al., 2012; Smale, 2006).

As women are often key producers and users of traditional crops, effective research and development of NUS also requires a gender-responsive approach (Elias, 2013). It is unclear whether researchers are receiving sufficient training to foster the strong interdisciplinary, collaborative, participatory and gender-responsive research required for NUS development. Current training and research environments primarily serve the major staple crops and commodities, and the concept of agricultural biodiversity is poorly covered in higher

agricultural education (Rudebjer et al., 2013), which hinders progress in NUS research and development.

In addressing the need for increased capacity on NUS research and development in sub-Saharan Africa, a series of seven training workshops were organized between 2010 and 2012, on the following topics, all with a focus on NUS plants:

- Scientific proposal writing (two courses)
- Experimental design and data analysis (two courses)
- Food systems: from agronomy to human health
- Value chain research
- Scientific writing and communication

The courses targeted young scientists from ten countries: Benin, Ghana, Mali, Nigeria, Senegal, and Ethiopia, Malawi, Mozambique, Kenya and Uganda. More than 1300 scientists in total applied for the courses, of which approximately 170 were accepted. Thus, for the majority of applicants, due to funding constraints, their training needs could not be met. This high demand for training showed a surprisingly strong interest in NUS research among young scientists. It also raised questions about the availability and quality of NUS training, what NUS research is currently being conducted, and the main constraints researchers face in this field. We investigated these questions through a survey that was administered by email to scientists who had applied to the training courses.

The courses were part of the project '*Building human and institutional capacity for enhancing the conservation and use of Neglected and Underutilized Species (NUS) of crops in West Africa, and Eastern/Southern Africa*', supported by the African, Caribbean and Pacific (ACP) Science and Technology Programme, funded by the European Union. The project was implemented by Bioversity International, Italy; International Foundation for Science (IFS), Sweden; Regional Universities Forum for Capacity Building in Agriculture (RUFORUM), Uganda; African Network for Agriculture, Agroforestry and Natural Resources Education (ANAFE), Kenya; Institut de Recherche et de Développement sur la Biodiversité des Plantes Cultivées, Aromatiques et Médicinales (IRDCAM), Benin; Plant Genetic Resources Research Institute (PGRRI), Ghana; University of Nairobi, Kenya and the University of Malawi.

Methods

A survey of 44 questions was prepared using 'SurveyMonkey', an online questionnaire software, taking approximately 20 minutes to complete. The survey was sent to 592 scientists in Eastern, Southern and West Africa, who had documented their interest in NUS research by their application to the aforementioned NUS training courses in 2010 and 2012 (many of the 1300 applicants had changed email addresses and could not be reached). The data collection took place in July and August 2013.

All analyses were performed in R version 2.15.2. The analysis involved calculation of summary statistics and contrasting results from East vs. West Africa and students vs. non-students using chi-square tests. There were very few significant differences between these groups of respondents, and so we only describe results for the full group of respondents.

Survey respondents

A total of 383 researchers (a response rate of 64.7%) responded to the survey, of which one third were women (Table 1). The age of respondents ranged from 24 to 57, with an average age of 37. Respondents came from 15 countries in Africa with 38% from eastern and southern African countries and the rest from West Africa. The greatest number of respondents came from Nigeria, followed by Ethiopia and Kenya. Combined, these three countries accounted for 63.7% of the responses. Benin, Ghana and Senegal were also well represented. By contrast, four countries, Côte d'Ivoire, Gabon, Togo and Zimbabwe, were represented by only one scientist each. Almost all (90%) of respondents resided in their home country. Of the 10% that were ex-patriot, half were residing in another African country and half elsewhere, usually studying for a higher degree.

Table 1. Nationality and gender of respondents.

Nationality	**Female**	**Male**	**Total**
Eastern and Southern Africa			
Ethiopia	6	50	56
Kenya	21	30	51
Malawi	5	10	15
Mozambique	0	4	4
Uganda	8	9	17
Zimbabwe	0	1	1
West Africa			
Benin	12	26	38
Cameroon	0	3	3
Côte d' Ivoire	0	1	1
Gabonese	1	0	1
Ghana	6	19	25
Mali	3	6	9
Nigeria	54	83	137
Senegal	9	14	23
Togo	0	1	1
Not provided	0	1	1
Total	**125**	**258**	**383**

The majority of participants in the survey (61%) had achieved a Master's degree and about a third (31%) had obtained a PhD. Only 2% had a Bachelor's degree alone and 6% did not indicate their level of education. Respondents' most common field of study was, by far, agriculture (59%). Many had also studied health and nutrition (10%), ecology/environmental science (10%), or forestry (8%). Fewer respondents had studied economics (4%) or social science (2%). The rest comprised other fields of study such as food science/technology, biotechnology, plant breeding, bioengineering, and pure biology fields like botany and microbiology. Nearly half of respondents (45%) were currently studying for a higher degree. Most respondents were affiliated with a university/college in a developing country (59%) or a national research institute (29%). The private sector was poorly represented in this survey.

A majority, 240 respondents (63%) were currently performing research on NUS. Another 100 (26%) were planing to do so in the future. Only 1% of respondents indicated they had no

plans of engaging in NUS research and 11% did not respond to the question. These groups, 43 respondents were excluded from the analysis.

Current NUS research

The results described in this section are based only on the respondents who were currently researching NUS (n=240).

Students dedicated a higher proportion of their time to NUS research than did the non-students: 46% of students and 23% of non-students allocated at least 60% of their working time to NUS. Half of the non-students spent 40% or less of their time on such crops. NUS research is often a part-time job (Figure 1).

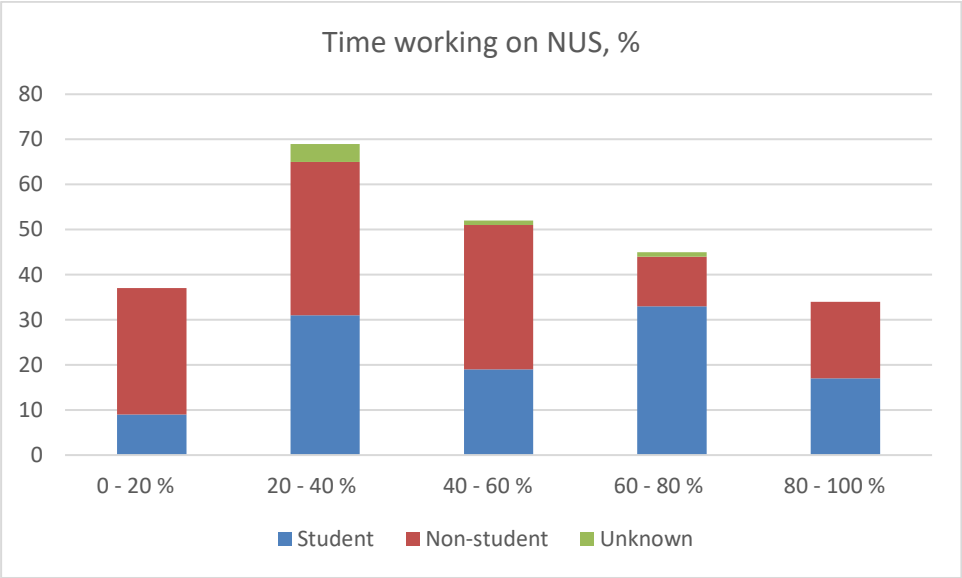

Figure 1. Proportion of working time dedicated to NUS research by students and non-students.

A wide diversity of NUS species was represented in respondents' research. The majority of researchers (61%) focused on just one type of NUS but over a third (39%) were researching a combination of NUS types, for example cereal and legume species. The most popular types of NUS studied were legumes and pulses, leafy vegetables and roots and tubers (Table 2). Among the most studied species were leafy amaranths, Bambara groundnut (*Vigna subterranea*), cowpea (*V. unguiculata*), yams (*Dioscorea spp.*), sorghum (*Sorghum bicolor)* and the multi-purpose *Moringa oleifera* tree, studied for its leaves, seeds, roots and oil. A small group of respondents was studying animals, which in some cases involved looking at the contribution of NUS plants to the nutrition and health of livestock. In total, the 240 researchers conducted research on 184 species in 148 genera and 64 families.

Table 2. Types and species of NUS considered in current research.

NUS Type	Total (N=240)	Most popular species (no. of respondents)	# species mentioned
Legumes	75	*Vigna subterranea* (15) *Sphenostylis stenocarpa* (10) *Vigna unguiculata* (8) *Phaseolus vulgaris* (5)	32
Leafy vegetables	67	*Amaranthus sp.* (22) *Solanum sp.* (10) *Telfairia occidentalis* (10) *Crassocephalum sp.* (6) *Corchorus olitorius* (6)	43
Roots and tubers	62	*Dioscorea sp.* (13) *Manihot esculenta* (10) *Colocasia esculenta (*10) *Ipomoea batatas* (10) *Cyperus esculentus* (6)	21
Cereals and pseuodcereals	52	*Sorghum bicolor* (9) *Pennisetum glaucum* (9) *Eleusine coracana* (7) *Digitaria exilis* (7)	12
Fruits and nuts	37	*Vitex. sp.*(4) *Vittelaria paradoxa* (3)	42
Plants with other uses*	52	*Moringa sp. (7)*** *Cola sp. (5)* *Jatropha sp.(5)*	32
Animals	10	All unique, including *Apis mellifera*, livestock, and farmed fish	8
Fungus	7	*Pleurotus sp.* (5)	9
Algae and seagrass	4	All unique, including *Arthrospira platensis*	3
No reply	5		

*Medicinal, timber, oil seeds, biodiesel, fibre, etc.

** There were actually 11 people studying *Moringa* but only seven people indicated that the purpose was for 'other' uses. The tree was also being studied for its edible leaves (5), seeds (3), and roots (3 respondents).

Most respondents' NUS research was purely biophysical in nature (36%) or combined biophysical and socio-economic research (47%). Only 13% of respondents' research focused only on socio-economic issues.

The most popular topic of NUS research was nutrition (36%; Figure 2). Other common topics were genetic diversity characterization and conservation, and aspects of NUS production such as agronomy, post-harvest processing, and value addition. The least addressed topics were gender and policy aspects, which were considered by only about 5% of the respondents. Most respondents' research (72%) addressed more than one topic.

In accordance with the fact that multiple topics were addressed by respondents' NUS research, the majority, 62%, of researchers also used more than one method to approach their NUS research. Experiments conducted in laboratories and research stations were the most

commonly used methods, followed by diversity characterization and socio-economic surveys (Figure 3). Participatory methods were among the least common, used by 23% of respondents, and seemed notably low among those investigating nutrition, conservation and value chains (Figure 4).

Gender was considered in 79% of NUS research projects at various stages of research. However, few considered gender in the formulation of research questions and hypotheses (25%), choice of methodology and approaches (22%), and data analysis stages (22%). Very few respondents (10%) considered gender in all these research stages and even fewer (7%) then also included gender in the dissemination phase of the research.

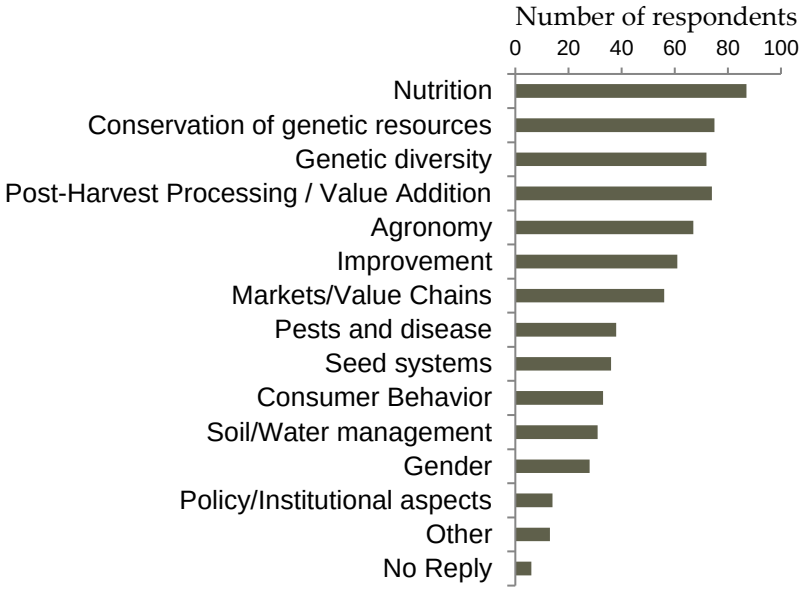

Figure 2. Topics addressed in NUS Research (n=240)

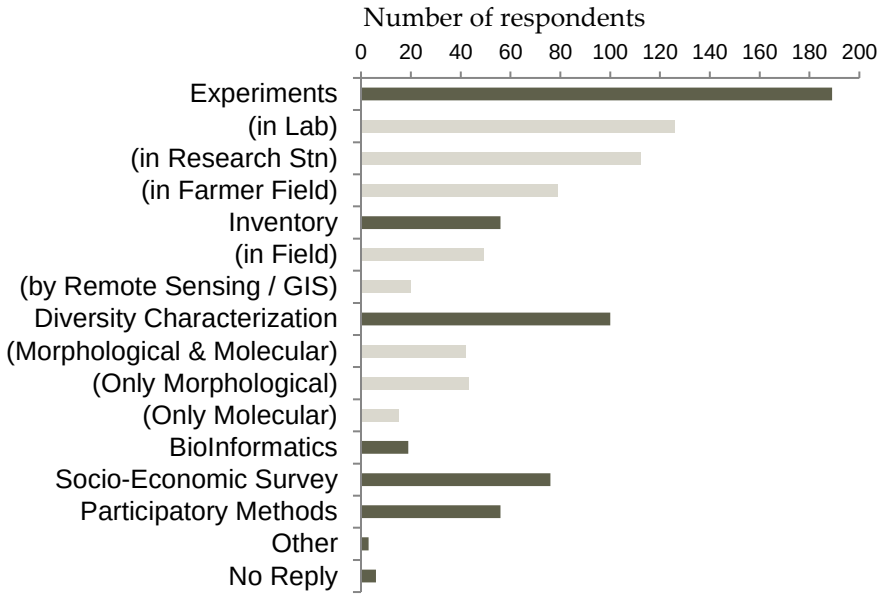

Figure 3. Methods used in NUS Research (n=240)

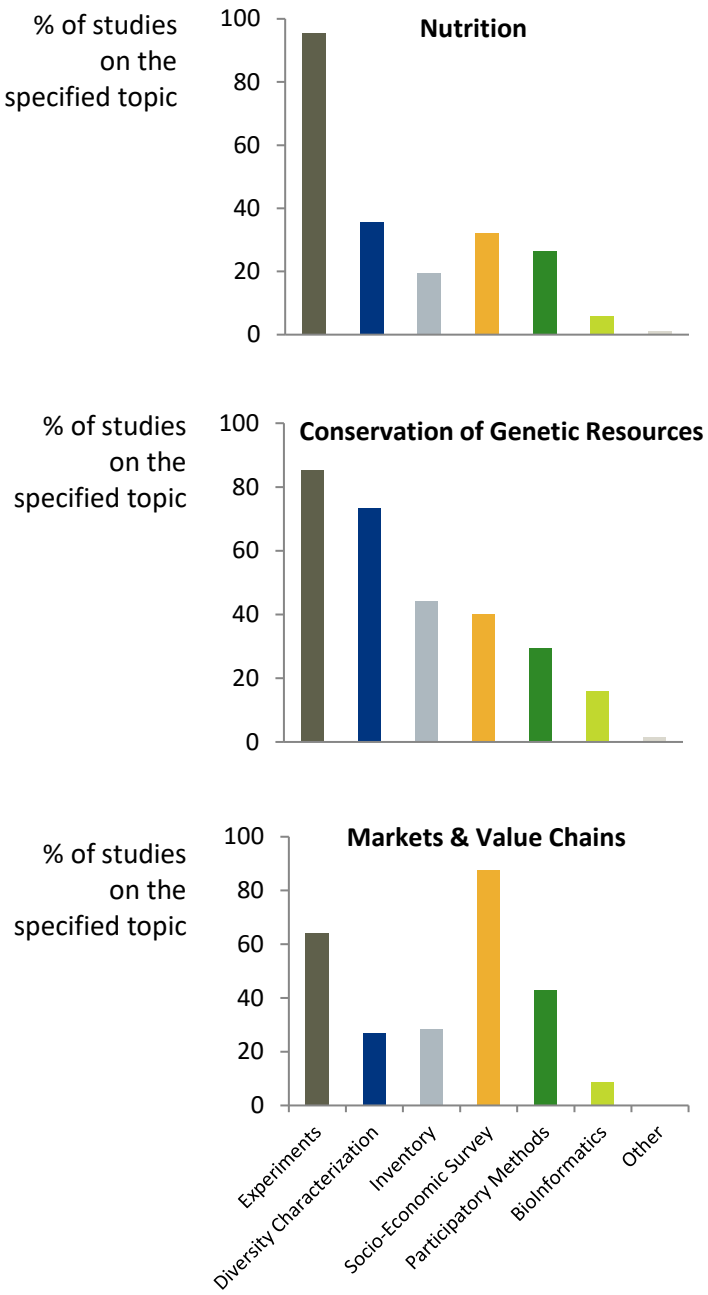

Figure 4. Percent of studies on nutrition (n=87), conservation of genetic resources (n=75) and markets and value chains (n=56) that used different methods of investigation.
Note: studies on a particular topic often addressed topics in addition to those shown.

NUS research capacity

This section and the following are based on responses from both current and potential NUS researchers (n=340).

How well did universities prepare respondents for NUS research? About half of respondents (51%) felt their education had prepared them well or very well to conduct research on crops including NUS. Another 30% reported that their education had given them adequate preparation. A much smaller number (18.8%) felt that their education did not prepare them very well or at all for NUS research. One third (35%) did not encounter NUS in the curricula of their most recent academic degree (Figure 5).

Thesis research and short training courses were important in developing NUS research capacity. Most respondents (81%) said their theses were related to NUS (Figure 5). Many (39%) had also attended short training courses on NUS in the past five years. Typically (22%) these were international training courses but relatively few took these courses nationally (10%) or in their own institution (9%).

In many cases, researchers were investigating topics they were not trained for in their previous degree. For instance, nutrition was the most popular topic of NUS research but, at most, 24% of those studying nutrition had been trained in this field (Figure 6). Be that as it may, it was common for NUS research to be carried out in interdisciplinary teams (65%) and the teams often made up the discrepancy in training to some extent. For instance, 61% of researchers investigating nutrition included someone on their team who was trained in the field. Researchers investigating value chains were, likewise, rarely trained in economics (14%), but 59% of these researchers had an economist on their team.

Only 7% of researchers looking at gender issues were trained in this topic in their previous degree but 71% had a gender-specialist on their research team. Many respondents (28%) had also taken a training course on gender in the past five years. Overall, 89% of researchers investigating gender had either been trained in gender in their previous degree, had a gender specialist on their team or had taken a supplementary training course on gender.

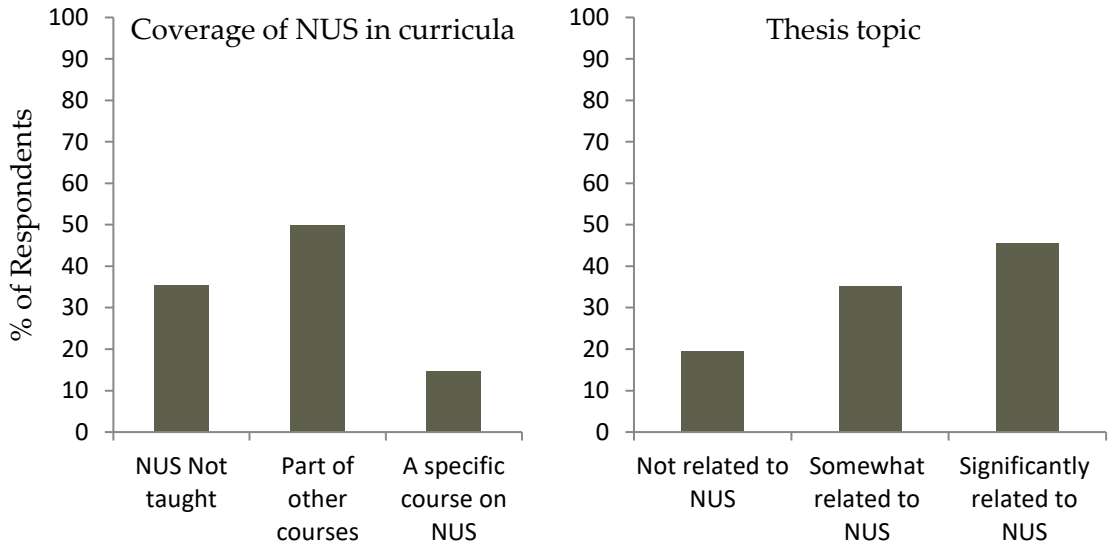

Figure 5. Coverage of NUS conservation or use in the curriculum of respondents' most recent academic degree and the extent to which their thesis related to NUS crops/trees.

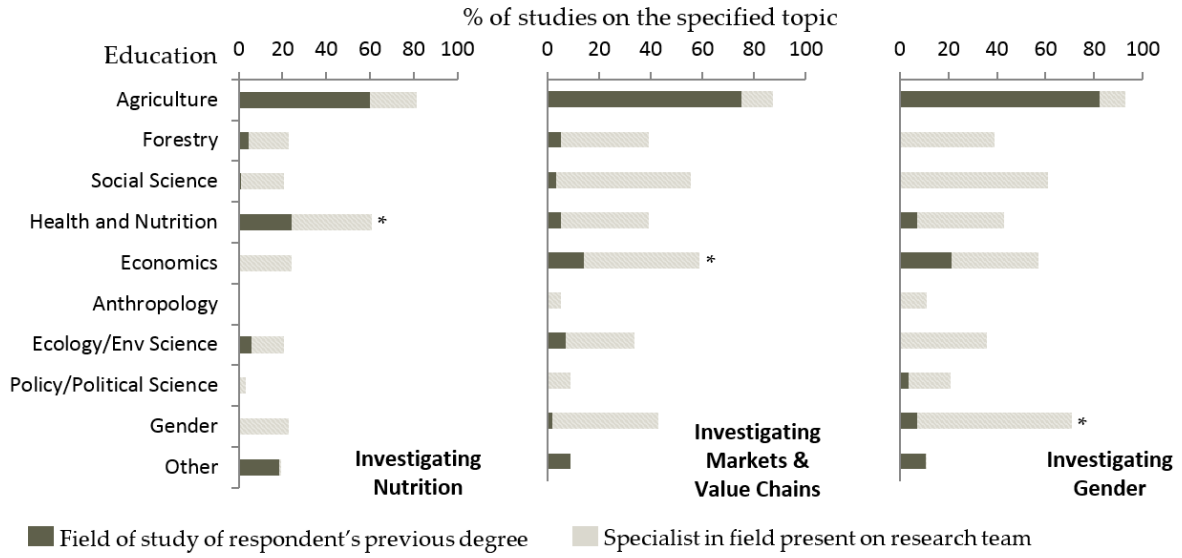

Figure 6. The percentage of researchers investigating nutrition (n=87), markets and value chains (n=56) and gender (n=28) who were educated in different fields of study (dark grey bars), and those who had other people of a specific specialization on their teams (light grey bars).

Organizational capacity and external support

NUS researchers were supported by their own organization more strongly in some aspects than in others (Figure 7). Collaboration within institutions was fairly common (57%). Access to mentorship on NUS was, however, rated as poor to non-existent by almost half of respondents. Less than a quarter of respondents indicated that their access to mentorship on their NUS research was very good or excellent. Access to mentorship on statistics and gender-responsive research were also seen as less than adequate by more than half of respondents.

In terms of facilities, laboratory quality was seen as poor to very poor by the majority of respondents. This was indeed recognized by 29% of respondents as a major constraint in pursuing NUS research. Lack of information on NUS constrained many respondents (19%), including information to help in identifying species and methodologies for cultivating them, which could relate to issues with internet and library access as well as the understudied nature of these species (Figure 7).

Regarding financial resources, 35% had received funding from their organization. About half of respondents currently engaged in NUS research (46%) were at least partially self-funded. We also asked respondents to describe the two or three most critical constraints they face as NUS researchers. By far, financial constraints were the most common, reported by as many as 70% of respondents. Inadequate facilities, equipment and materials were mentioned by 29%, and human resource constraints by 25% of respondents, respectively (Table 3).

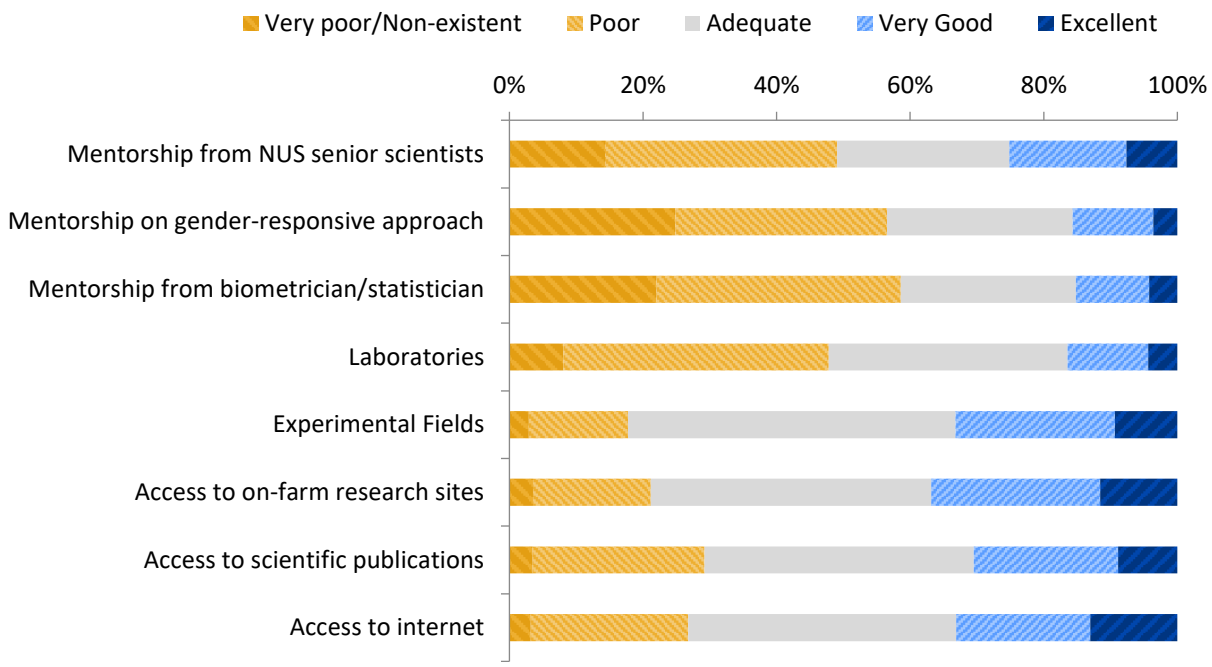

Figure 7. Perceived support within home organization for NUS research in terms of access to mentorship and quality of facilities. Missing values omitted from percentage calculations.

Table 3. Constraints to NUS research.

Constraints to NUS research	**% of respondents**
Financial	**70%**
Facilities/materials	**29%**
Inadequate equipment and lab materials	18%
Inadequate facilities	15%
Human resources	**26%**
Lack of necessary skills in research team	9%
Missing supportive networks and collaboration	6%
Non-availability of training	6%
Few experts and mentors	4%
Insufficient time	3%
Information, methods and data on NUS	**17%**
External support	**16%**
Lack of interest/priority by donors, government stakeholders	14%
Lack of supportive policy	4%
Lack of germplasm or access to germplasm	**8%**
Lack of seed/germplasm	6%
Access to seed/germplasm	2%

External support for NUS research

The extent to which the external environment was supportive of NUS research varied greatly (Figure 8). Sixty-one per cent of respondents found it poor or non-existent, while 13% reported that it was very good or excellent. Half of respondents rated the level of national policy support as poor or non-existent, while one tenth experienced very good or excellent policy support.

A majority reported that their participation in networks or professional associations related to NUS was poor or non-existent both at national and international levels (Figure 8), indicating a certain scientific isolation. Still, many researchers benefitted in various ways from collaboration and partnerships outside of their own organization. For instance, 37% received funding from national or international sources and 60% reported collaboration outside of their own organization in their NUS research, either with national (37%) or international (33%) organizations. One third (33%) of respondents had attended a conference related to NUS in the previous five years.

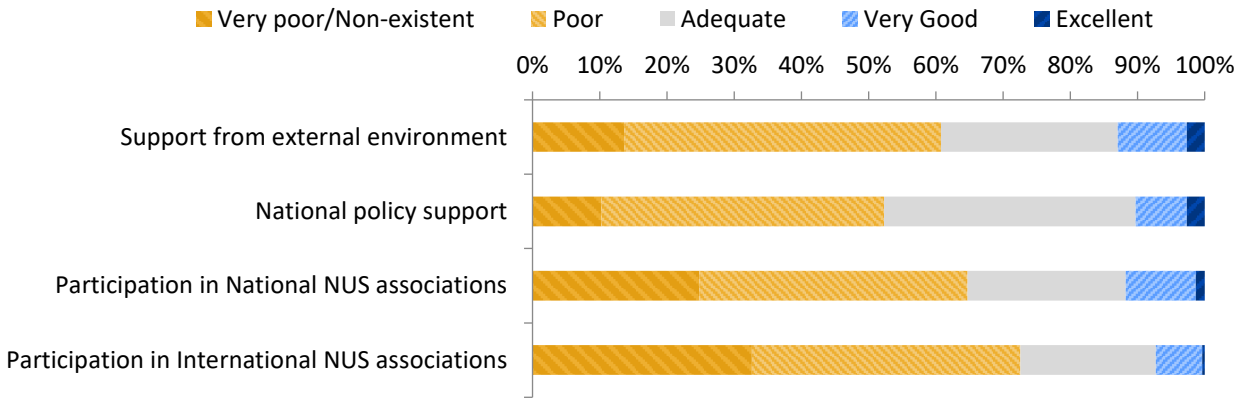

Figure 8. The external environment for NUS research as perceived by African researchers interested in NUS (n=340). Missing values omitted from percentage calculations.

Discussion

This survey demonstrated that African researchers are studying a wide diversity of NUS from a variety of angles including their genetic diversity, nutritional, agronomic, and market potential. The fact that respondents were studying 184 different species indicates as well that new knowledge is being generated for a wealth of crop and tree diversity in sub-Saharan Africa, which could contribute to enhancing the resilience, nutritional value, and sustainability of food systems on this continent. The high number of species under study also hints, however, that research efforts are likely to be fragmented and lacking a critical mass in terms of addressing the numerous constraints to value chains of each specific crop.

Researchers used a range of methods to investigate NUS, but these mostly did not involve participatory methods. Most of the studies involved laboratory analyses of nutritional value, or characterization of diversity. These methods alone are insufficient to address the many value-chain bottlenecks that these crops face for their use enhancement. More studies orientated towards value chains and involving participatory methods that engage communities in the research are necessary to ensure that actions are targeted and relevant, and would increase the likelihood of research results being put into use.

There was significant awareness of gender issues among the African scientists surveyed, but gender was not strongly considered in most research projects. NUS research should ideally be gender-responsive as women are often the main producers of traditional crops. Many respondents said that they considered gender at some point in their research but very few did so throughout the research process. Gender aspects were rarely addressed at the design stages of the study. For best results, gender should not be tagged on at the analysis phase; rather it should be embedded in the methodologies from conceptualization of the research to the dissemination of results. Increased emphasis on participatory, gender-responsive research approaches and training in this field, could address this issue.

The survey was not conclusive regarding the coverage of NUS issues in formal education. Half of the respondents felt that their formal education had prepared them well or very well for NUS research. Still, more than one third had not encountered university courses that covered NUS. Integrating NUS issues in higher education could also help build capacity to research native crop species or upgrade their value chains. Teachers' training, provision of good training materials, and curriculum review could support this process.

Conducting thesis research on NUS played an important role in developing capacity for work in this field. Further strengthening of NUS thesis research opportunities would be an effective way of quickly increasing overall research capacity on NUS. Offering short training courses on NUS for working professionals would also be important in developing capacity. These training opportunities should be supported and increased.

Access to mentorship on NUS, gender and biometrics/statistics was an issue. These findings highlight a capacity limitation for NUS research, which could be addressed via on-the-job training, institutional strengthening, improved networks and formation of communities of practice. Networks and collective action also help to build a critical mass for more rapid research progress on selected priority crops. Social networks can play a role in connecting scientists working in isolation, and sharing knowledge and ideas within and between countries.

Funding limitations and inadequate access to, or quality of, facilities often constrain NUS researchers. However, this study did not make a comparison with the situation facing scientists working on major staple crops and commodities. This finding could then reflect a general problem in academic institutions in sub-Saharan African, rather than one specific to NUS. It is however likely that funding opportunities for NUS research might be poorer than for the dominant crops, given that investment in agriculture research already is low in many African countries.

There is much room for improvement of external support, including policy support for NUS research, according to a clear majority of respondents. In particular, there is a deficiency of national and international associations and networks dedicated to NUS.

The fact that hundreds of scientists in this subset of countries in Eastern, Southern and West Africa conduct research on NUS is encouraging. Their combined effort will generate new knowledge on a large number of NUS of importance to food and nutrition security and livelihoods on the continent. Such knowledge on crops that are often locally adapted can contribute to climate change adaptation. The capacity to harness such knowledge and bring

it into use for development through proper sharing among researchers and effective two-way communication with non-scientists are also other important aspects that would in fact need to be strengthened.

Acknowledgements
This study was linked to the project 'Building human and institutional capacity for enhancing the conservation and use of Neglected and Underutilized Species (NUS) of crops in West Africa, and Eastern/Southern Africa' under the ACP-EU Science & Technology Programme, implemented by the African, Caribbean and Pacific Group of States (ACP) Secretariat and financed by the European Union.

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