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Research Application Summary

Factors influencing farm genetic diversity of sorghum in northern and eastern Uganda

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Abstract

Loss of diversity in plant genetic resources has become a matter of increasing concern for nations due to challenges associated with climate change and feeding the ever increasing world population. The diversity within plant genetic resources is required to guard against any future challenges making the conservation of these resources critical. On farm conservation, a subset of *insitu* conservation has become one of the most popular methods of conserving plant genetic resources as it encourages utilization as well as facilitates continued natural evolution of the crops while in the field. Mitigating loss of plant genetic diversity on farm will require understanding of farmers' crop management decisions, factors that influence their decision on whether to conserve genetic diversity as well as understanding farmer knowledge and perceptions of diversity. The purpose of this study therefore was to determine the factors influencing farmers to conserve or discard sorghum varieties on their farms in Eastern and Northern Uganda. This study utilized a quantitative research approach where data were obtained through a survey. The data were subsequently tabulated and responses summarised and expressed in percentages. Preliminary results indicate that market and culture have a major influence on the types of sorghum grown by the farmers in the three districts. Of the three districts, Agago had the most sorghum diversity having a total of 19 sorghum types identified by farmer names. The conservation of diversity within the communities in this district can be attributed to their culture of seed sharing among farmers, neighbours and mothers passing on seed to their daughters. In Agago, sorghum is majorly grown for home consumption, while in Apac and Serere, farmers were market oriented and tended to discard sorghum types that did not have ready market. The study is still on-going but it is hoped that the information generated will contribute to designing appropriate strategies to mitigate losses of diversity in sorghum, an important staple food in the Eastern and Northern Uganda.

Key words: Crop genetic diversity, plant resources, *Sorghum bicolor*, Uganda

Résumé

La perte de la diversité génétique des ressources végétales est devenue un sujet de préoccupation croissante pour les pays en raison de problèmes liés au changement climatique et à nourrir la population de plus en plus dans le monde. La diversité génétique au sein des ressources végétales est nécessaire pour se prémunir contre toute contestation future rendant la conservation de ces ressources essentielle. Sur la conservation à la ferme, un sous-groupe de la conservation *in situ* est devenue l'une des méthodes les plus populaires de la conservation des ressources génétiques végétales parce qu'elle encourage l'utilisation et facilite l'évolution naturelle continue des cultures tandis pendant qu'elles sont toujours dans le champ. Pour atténuer la perte de la diversité génétique végétale à la ferme, il faudra comprendre les décisions de gestion des cultures par les fermiers, les facteurs qui influencent leur décision de conserver ou pas la diversité génétique ainsi que leur compréhension des connaissances et la perception de la diversité. L'objectif de cette étude était donc de déterminer les facteurs qui influencent les agriculteurs à conserver ou à éliminer les variétés de sorgho dans leurs fermes de l'Est et du Nord de l'Ouganda. Cette étude a utilisé une approche de recherche quantitative où les données ont été obtenues grâce à une enquête. Les données ont ensuite été analysées et les réponses résumées et exprimées en pourcentage. Les résultats préliminaires ont indiqué que le marché et la culture ont une influence majeure sur les types de sorgho cultivés par les agriculteurs dans les trois districts. Parmi les trois districts, Agago avait la plus grande diversité de sorgho ayant un total de 19 types de sorgho identifiés par des noms d'agriculteurs. La conservation de la diversité au sein des communautés dans ce district peut être attribuée à leur culture de partage des semences entre les agriculteurs, les voisins et les mères qui passent sur les semences à leurs filles. En Agago, le sorgho est majoritairement cultivé pour la consommation à domicile, tandis qu'à Apac et Sérère, les agriculteurs étaient inclinés vers le marché ayant tendance à rejeter les types de sorgho qui ne sont pas facilement vends au marché. L'étude est toujours en cours, mais il est anticipé que l'information générée contribuera à l'élaboration de stratégies appropriées pour atténuer les pertes de diversité du sorgho, un aliment de base important dans l'Est et le Nord de l'Ouganda.

Mots clés: diversité génétique des cultures, ressources végétales, *Sorghum bicolor*, Ouganda

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Background

The world's food supply depends on about 150 plants resources, of these, only 12 provide three quarters of the world food (IDRC, 2000; FAO, 2008). Four of the 12 crops (rice, wheat, maize and sorghum) meet most of the world human energy needs (Macauley, 2015). Further, most of the human dietary protein requirement of developing countries are met by just beans, groundnut, soybean and cowpea (CGIAR, 2012). Genetic diversity within these crop resources is essential to ensure sustainable production of these crops.

As the world population increases and climatic conditions change, the ability of those few crops to continue feeding the world will depend partly on the available genetic diversity within the available crops. According to the United Nations Department of Economics and

Social Affairs/Population Division report of 2004, the world population is projected to increase up to 8.9 billion by 2050 from the 6.1 billion in 2000, an increase of 47 percent. It is also estimated that a combination of pests and diseases associated with climate change could result into 85% losses in attainable yield (Gautam *et al*., 2013) and, consequently, a loss in crop diversity. Given the dependency of human beings on a few food crops which are under threat from the ever increasing world population, and biotic and abiotic stresses from climate change, maintaining the diversity within these food crops is paramount for securing food for feeding the current and the future generations. Presence of a wide range of crop resources will most likely provide a diverse array of plant genes that can ensure appropriate breeding response to the above global challenges (Burke *et al*., 2009). Carpenter (2011) maintains that crop genetic diversity is source of continuing advances in yield, pest resistance and quality improvement.

Despite the importance of crop genetic diversity various studies have documented losses in diversity of these plant resources, a phenomenon called genetic erosion. Genetic erosion is defined as the loss of individual or combination of genes such as those found in local landraces (FAO, 2008).This phenomenon has been evident since the 19th century (Porceddu *et al.*cited by Heal *et al*., 2004). who noted three phases of genetic erosions in history. The first was in the 19th century in Europe which was ensuing from the works of the early breeders breeding for elite varieties, the second in the mid 20th centuries associated with an effort to improve productivity in non industrialized countries and the third associated with the push for uniformity of produce.

According to Saad *et al*. (2015) the loss of plant genetic resources is as a result of poverty, poor economic development and market integration while Day-Rubenstein (2005) pointed out that habitat loss, conversion from landrace to scientifically bred and genetically uniform varieties as the major causes of plant genetic diversity. Demographic changes, pests and diseases outbreaks, consumer preferences, lack of knowledge on conservation of plant resources and unsustainable breeding programs also contributed to the loss of plant resources and consequently loss in the diversity within crops (Hammer and Teklu, 2008). Gore (1992) considered that genetic erosion as the single most serious strategic threat to the global food system. Considering that genetic erosion is a threat to the livelihood of people, emphasis on conservation of diversity within resources is fundamental.

On-farm conservation is one of the ways diversity within plant resources can sustainably be managed and utilized. It is a subset of *insitu* conservation that is increasingly becoming attractive because of its dynamic features (ability to allow the continuation of co evolutionary processes), capacity to maintain crop diversity, the indigenous knowledge associated with it and the opportunity it opens up to link conservation and rural development (Wale *et al*., 2011). Farmers who are the main stewards of the plant resources (through on farm conservation) will maintain diversity within a crop to an extent that benefits them. Wale (2008) pointed out that conservation of diversity within a crop involved an opportunity cost, and that this cost is higher if the farmer is able to access better markets and inputs. The decisions that these farmers make, ultimately influence the diversity seen on their fields. Jarvis and Hodgkins (1999) found that farmers' decisions at planting, managing, harvesting and processing of their crops affected the genetic diversity of crop populations. It is estimated that 75 percent of the world's crop genetic diversity has been lost as a result of farmer decision to discard or return varieties (FAO, 1999). Farmers' decisions have left the diversity within crop resources constantly changing over time.

In Uganda, little is known about the existing on-farm diversity within most of the food crops and the factors that influence farmers' decision to maintain this diversity. The causes, magnitude and consequences of crop diversity fluctuations are context specific (Wale *et al.*, 2011). Therefore this study examined sorghum farm diversity in Agago, Apac and Serere districts in northern Uganda, a major sorghum growing area in the country. It is hoped that the knowledge obtained from this study will help in planning for sustainable agriculture. The study therefore sought to; i) document farmers' knowledge and perception on the importance of genetic diversity, and ii) identify factors that influence on-farm conservation of genetic diversity in sorghum. In this study genetic diversity is used in reference to different types/ varieties (local and improved) of sorghum grown in the farmers' fields and is the focus for this study.

The rationale for this study is to contribute to development of on-farm conservation strategies and policy decision for sustainable management and utilization of sorghum genetic diversity which does translate to a sustainable livelihood for communities that are highly dependent on this crops. The study will also provide information that will be needed to design appropriate interventions for maintaining diversity within sorghum on farmer fields as well as point out collaboration areas for the different stakeholders.

Literature summary

Sorghum (*Sorghum bicolor)* is an important cereal crop rich in carbohydrate providing roughly 30% of calories consumed in Africa (FAO, 2008). In Africa, it is the second most important cereal after maize (Macauley, 2015) and in Uganda, it ranks 3rdafter maize and finger millet (Ainembabazi *et al*., 2005). It is a multifunctional crop consumed as food, porridge and an important recipe for beer brewing (Kigozi *et al.,* 2013); it is also used as feed for poultry and livestock. Researchers have also found that sweet sorghum has the potential for production of ethanol, a bio fuel, because of the synthesizes sucrose, glucose and fructose in its stalk (Jia *et al*., 2013). Sorghum's tolerance to drought makes it a crop of choice in Northern and Eastern Uganda which are quite semi-arid. As such, mantaining high genetic diversity within sorghum crops is important for mitigating household food insecurity in those regions.

Crop genetic diversity is defined as a variation in genetic composition within an individual crop or among crop species (Malik and Singh, 2006). Diversity has been and remains significant in maintaining and increasing agriculture productivity over a wide range of conditions (Heal *et al*., 2004; Carpenter, 2011). It also provides useful traits needed by both informal and formal plant breeding to meet challenges such as adapting crops to the changing climate conditions or disease outbreak (FAO, 2008). For small-holder farmers this diversity ensures sustainable income as well as guaranteed household food security. Genetic diversity within crop species provides an insurance against total crop failure and subsequent famine. The best example in history of total crop failure due to limited genetic diversity was the outbreak of potato blight in Ireland which ravaged all the potato fields in the country causing 'the Great Famine of the 18thcentury. Another case was in the United States of America in the 1970s where an outbreak of southern leaf blight wiped out the maize with Texas male sterile cytoplasm in most maize-growing areas of the USA, while maize with normal cytoplasm was resistant to the pathogen (Singh and Srivastava, 2012).

Local varieties have been said to contain a diverse gene pool compared to improved varieties. These varieties are preferred by farmers because of their 'good taste,' adaptability to their farming conditions and their little or no use of production input like fertilisers. On the other hand, improved varieties contribute to agricultural growth and poverty reduction directly from the high yields obtained which generate higher incomes and also provide an opportunity for employment (Gollin *et al.*, 2005). However, their adaptability to different environments is attributed to genes from the local varieties. Hence local and improved varieties play a complimentary role and are needed in a cropping system to meet both the private needs of farmers and public need for agriculture sustainability.

It is not yet clear as to whether a loss in genetic diversity has occurred in all crop resources as some researches assert. One thing that is clear is that farmers who are the major custodians of these resources will influence the crop diversity through the management decision they apply in their fields. Their perceptions of diversity and its different values will influence their willingness to conserve diversity in their fields. The farmers' decisions are made in view of economic, social, natural and historical factors (Cox and Wood, 1999). Jarvis and Hodgkins (1999), categorized farmer's decision making that affects crop diversity into five aspects; what agro-morphological characteristics to select for, farming practices to use, where to plant, size of plant population and seed source. Leclerc and D'Eeckenbrugge (2012) argued that the social factor was equally important when understanding factors that affected crop diversity. They classified the social factors into that farmer's practices, perceptions, social identity and community context collectively.

Methodology

The study was carried out in Agago and Apac districts in Northern Uganda and Serere district in Eastern Uganda. According to the Uganda Census of Agriculture 2009, the Northern and Eastern regions are the highest producers of sorghum hence the rationale for the selection of these areas for our study. This preliminary study utilized a quantitative approach; involving a sampling survey. From each district, three sub-counties with a high incidence of farmers growing sorghum were purposively selected and in each sub-county households growing sorghum were randomly selected. A total of 94 farmers were interviewed using semi structured questionnaires. The 1984 ICRISAT standard sorghum descriptor was utilized when identifying and differentiating the types of sorghum grown by farmers.

Research application

Farmers' knowledge and perception of diversity. Farmers could differentiate the types of sorghum that were in their fields by grain colour, plant height, fluorescent head shape, taste and grain size. From their experience of growing and utilizing the different types of sorghum, the farmers were able to tell which type of sorghum had low yields, high yields, matured early or late, prone to bird attack, had no market, was hard to thresh, susceptible to drought, pest and disease (strigga attack) and made good flour. It is those same reasons they gave for discarding some of the sorghum types. Most farmers were aware that they had more than one type of sorghum variety in their fields which they attributed to seed unavailability which causes them to mix different types of sorghum, small pieces of land allocated to sorghum and yet a need to grow more than one type of sorghum, impure seed from the local market and bee activity. Those that did grow more than one type of sorghum deliberately did so for insurance against hunger giving reason that different types had different maturity rates thus provided food at different points in time.

Factors that influence farmer's choice to conserve or discard the different types of sorghum from their fields. Serere and Apac farmers were more market oriented than the Agago farmers, and this is because they had ready market for their sorghum with the Soroti traders and Eager Lager Brewery. Most farmers in Apac procured seed because the companies or stores from which they buy the seed link them to buyers or even purchase the harvest from the farmers. As a result, this has led to farmers accidentally discarding certain sorghum types as the local markets, seed companies and shops are likely to stock seed that is preferred by the market/buyers. It was however noted that farmers that procured their seed from local markets had three to five types of sorghum varieties in their fields. In Serere, a number of farmers used seed from previous season and those that procured seed, it was mostly because they had had in the previous season low yields and so had consumed their entire harvest. On the other hand most of the Agago farmers did not procure seed, most women acquired seed from their mothers, neighbours and others did not reserve seed to be used for the next season . "It is not profitable to buy the seed seasonally and yet

Table 1. Farmers' sources of sorghum seed in the different districts (% responses)

Factor	Agago	Apac	Serere
Local market	34	26	35
Shop/ stores	-	47	8
Reserved from previous season	34	22	42
Victoria Seed Company	-	4	-
Neighbour / other farmers / friends	11		4
Mother	20	-	-
Operation Wealth Creation*	-	-	4
Trading centre			4

*Operation Wealth Creation is a Uganda Government Initiative to avail improved seed/breeds to farmers

Table 2. Household characteristics

Districts	Total number of respondents	Male	Female	Decision on which crop to grow	Average number of sorghum fields	Average number of sorghum types in the fields	Deliberate growing of more than 1 type of sorghum (%)
Agago	34	14	22	Joint	2	3	18
Apac	35	20	15	Husband	2	1	50
Serere	23	8	15	Joint	2	2	42

sorghum is majorly grown for home consumption," most farmers argued. The rich heritage of mothers passing on seed to their daughters and seed sharing, supported maintenance of certain sorghum types within a community and spread of some sorghum types to other communities.

Apac and Serere farmers grew their sorghum on relatively large pieces of land and were very keen in selecting the type of sorghum to plant unlike for the case of Agago farmers. This can be traced back to the need by Apac and serere farmers to meet the market requirements and demand. Farmers in Apac and Serere that deliberately grew more than one types of sorghum did so because one type was grown for the market while the other was for home consumption (made good flour for bread and therefore grown for home consumption). It is however to be noted that the type of sorghum varieties for home consumption were grown on relatively smaller pieces of land as compared to those types grown for sale. On the other hand, most farmers in Agago claimed not have deliberately grown more than one type of sorghum even yet their fields had a varied number of sorghum types. They attributed the diversity of sorghum in their fields on seed sources and bee activity. These farmers also added that if they had free access to uniform seed, they would discard their current seed.

Agago had the most diverse number of sorghum types (19) that were identified by the farmers using local/ indigenous names. The most popular types were *Okwara* and *Otara* which were named after the colour of their grains, red and white, respectively. There were preferred for home consumption and also had demand in local markets. *Labworo* and *Lakitgum* were the other popular types and these were preferred by traders for local and regional markets. In Apac, 11 types of sorghum were identified by the farmers, the most popular type being Sila (trade name) also called Epuripur. It is a large grained cream coloured sorghum and this was preferred by the breweries. *Abiir* and *Bell Atar* were the preferred for the traditional varieties and were grown for home consumption and for the local markets as the farmers claimed that these two types of sorghum made good flour for bread. In Serere, most of the farmers interviewed could differentiate the sorghum types but were not aware of the names of the sorghum types they had in their fields. In all, 13 types of sorghum were identified by farmers with *Arenga* being the most popular. One definite observation

Table 3. Farmer reseasons for discarding sorghum types in the different survey districts (% responses)

Reason	Agago	Apac	Serere
Seed unavailability	29	29	6
Late maturity	7	19	6
Low yield	14	-	15
Bad flour	21	-	-
Hard to grind	14	5	-
No ready market	-	23	38
Small seed	15	-	-
Strigga	-	5	-
Birds	-	9	17
Height	-	5	6
Labour intensive	-	5	-
Drought	-	-	6
Pest and diseases	-	-	6

was that most farmers in Serere grew the red grained sorghum as this type was preferred by most markets. White grained sorghum was grown especially by women for home consumption as it made 'good bread,' but had high bird attack.

The major problem faced by sorghum farmers in Agago is the strigga weed and very hot sunshine that they claimed caused reduction in the yields. On the other hand, the major problem in Apac was that the types of sorghum grown easily got spoilt at storage and so farmers hardly reserved seed for the next season. There was also widespread destruction of sorghum by birds that reportedly prefered the white and cream grained sorghum which most farmers in this district specialized in growing. In Serere, their biggest challenge was the long droughts that led to losses in produce and consequently low yields, leaving some farmers with no seed to reserve for the next season.

Seed unavailability has driven most farmers in Agago and Apac to discard certain types of sorghum. Farmers in those districts claimed that while in refugee camps they received seeds from relief agencies but after leaving the camps most farmers could not access that type of seed and so took up new types of sorghum. Others continued to use seed passed down from the elders. In Agago farmers discarded sorghum that they claimed made' bad flour' in terms of taste and colour and was hard to grind. This could be because their main priority for growing sorghum was for home consumption. Farmers in Apac and Serere discarded sorghum types that did not have ready market because these farmers were market oriented. In addition, these farmers were also more likely to discard sorghum that was very tall and late maturing, characteristics common in the local sorghum varieties.

Conclusion

The study investigated two major questions: 1) What is farmer's knowledge and perception of genetic diversity; 2) What factors influences on-farm conservation of sorghum genetic diversity. The findings indicate that market has a big influence on the types of sorghum grown especially by Apac and Serere farmers. These farmers discarded seed that did not produce high yields and did not have ready market. Culture also plays an important role in the maintenance of sorghum types within communities in Agago through sharing seed and mothers passing on seed to their daughters. Most farmers were aware of the diversity they possessed in their fields and most female farmers were likely to grow more than one type of sorghum for household food security. This is because women are more geared towards growing crops that feed the families in these regions.

In the subsequent research, markets issues will be further explored, investigating the different markets (buyers/consumers) these farmers produce for as well as identifying the types of sorghum preferred by these different markets. It is also planned to examine crop production and management practices, and their influence on the maintainance or disappearance of the different types of sorghum in farmer fields.

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References

Ainembabazi, J.H., Bashaasha, B., Mugisha, J., Pender, J.P. and Hyuha, T.S. 2005. Technological change in sorghum production in Eastern Uganda. *African Crop Science Conference Proceedings* 7:947-954.

Burke, M.B., Lobell, D.B. and Guarino, L. 2009. Shifts in African crop climates by 2050, and the implications for crop improvement and genetic resources conservation. *Global Environmental Change* 19(3):317–325. http://doi.org/10.1016/j.gloenvcha.2009.04.003

Carpenter, J. E. (2011). Impact of GM crops on biodiversity. GM Crops, 2(1), 7–23. http://doi.org/10.4161/gmcr.2.1.15086

Consultative Group for International Agriculural Research (CGIAR). 2012. Leveraging legumes to combat poverty, hunger, malnutrition and environmental degradation. CGAIR. pp. 1-236.

Cox, T.S. and Wood, D. 1999. The nature and role of crop biodiversity. In: Wood, D. and Lenné, J. (eds.). Agrobiodiversity: Characterization, utlization and management. CAB International,Wallingford. pp. 35-57.

Coulibaly, O., Alene, A.D., Manyong, V., Sanogo, D., Abdoulaye, T., Chianu, J., Kamara, A., Tefera, H. and Boukar, O. 2009. Situation and outlook for cowpea and soy bean Sub-Saharan Africa: report of the the Tropical Legumes II Project in West and Central Africa, (December). pp. 1–35.

Day-Rubenstein, K., Helsey, P., Shoemaker, R., Sullivan, J. and Frisvold, G. 2005. Factors influencing trends in crop genetic resources. *An Economic Appraisal (EIB)* 2:12-17 Economic Research Service USDA.

FAO. 1999. Women: Users, preservers and managers of agrobiodiversity, available at www.fao.org/FOCUS/E/Women/Biodiv-e.htm.

FAO. 2008. CGRFA plants use them or lose them. https//www.fao.org/nr/cgrfa, accessed 21/1/2016.

Gautam, H.R., Bhardwaj, M.L. and Rohitashw, K. 2013. Climate change and its impacts on plant diseases. *Current Science* 105:1685-1691. http://doi.org/10.1016/j.eswa.2010.09.036

Gollin, D.O., Morris, M.I. and Byerlee, D.E. 2005. Technology a doption in ntensive post - green revolution systems. *American Journal for Agriculture Economics* 87(5):1310-1316.

Gore, A. 1992. Earth in the Balance: Ecology and the human spirit,Houghton Mifflin, Boston MA

Hammer, K. and Teklu, Y. 2008. Plant genetic resources: Selected issues from genetic erosion. *Journal of Agriculture and Rural Development in the Tropics and Subtropics. Genetic Resources and Crop Evolution* 109(1):15–50. doi 10.1007/s10722-005-1145-8.

Heal, G., Walker, B., Levin, S., Arrow, K., Dasgupta, P., Daily, G., Starrett, D. 2004. Genetic diversity and interdependent crop choices in agriculture. *Resource and Energy Economics* 26(2):175–184. http://doi.org/10.1016/j.reseneeco.2003.11.006

International Development Research Centre (IDRC). 2000. Fact and figures on food and biodiversity. https//www. idrc.ca/en/article/facts-figures-food and biodiversity.

Jarvis, D. and Hodgkin, T. 1999. Farmer decision making and genetic diversity. In: Brush, S. (ed.). Genes in the Field: On-Farm Conservation of Crop Diversity. CRC press.

Jia, F., Chawhuaymak, J., Riley, M.R., Zimmt, W. and Ogden, K.L. 2013. Efficient extraction method to collect sugar from sweet sorghum. *Journal of Biological Engineering* 7:1. http:// www.jbiolen.org/content/7/1/1.

Kigozi, J., Byaruhanga, Y., Banadda, N. and Kaaya, A. 2013. Characterisation of the physico-chemical properties of selected white sorghum grain and flours for the production of ice cream cones. *The open Food Science Journal* 7: 23–33. http://doi.org/10.2174/1874256401307010023

Leclerc, C. and d'Eeckenbrugge, G.C. 2012. Social organization of crop genetic diversity. The G/ ?? E/ ?? S Interaction Model. *Diversity Journal* 4: 1-32. http://doi.org/10.3390/d4010001

Macauley, H. 2015. Cereal crops: Rice, maize, millet, sorghum, wheat. Background paper: An action plan for Africa Agricultural Transformation. pp. 1-36: Abdou Diouf Int Conference center Dahar, Senegal.

Malik, S.S. and Singh, S.P. 2006. Role of plant genetic resources in sustainable agriculture. *Indian Journal of Crop Science*, 1(1-2):21-28.

Saad, N., Sperling, L. and Ashby, J. 2015. Farmers and plant genetic resources, VIII. Retrieved from http://www.eolss.net/Sample-Chapters/C17/E6-58-07-13.pdf

Singh, R. and Srivastava, R.P. 2012. Southern corn leaf blight: An important disease of maize. *An Extension Fact Sheet* I(I):334-337.

Wale, E. 2008. Challenges in genetic resources policy making: Some lessons from participatory policy research with a special reference to Ethiopia. *Biodiversity and Conservation* 17(1):21-33.

Wale, E., Drucker, A.G. and Zander, K.K. 2011. The economics of managing crop diversity on-farm. Case studies from the genetic resources policy initiative. pp. 1-157. Earthscan Ltd Dunstan House, 14a St Cross street. London ECIN 8XA, UK.