UNIVERSITY OF BIRMINGHAM

DEVELOPMENT OF CROP WILD RELATIVE CONSERVATION AND USE STRATEGY FOR WEST AFRICA

By

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ABSTRACT

Crop wild relatives (CWR) are wild plants with close affiliation to cultivated crops, with resilient traits for crop improvement and climate change adaptation. In this study, 1651 CWR were compiled into a checklist template, and using three criteria of crop economic value in West Africa, CWR closeness to related crops, and threat status, 102 priority CWR were selected. Prioritization was used to reduce the number of CWR in a checklist to a manageable number for active conservation. *In situ* and *ex situ* conservation gap analyses of the 102 West African priority CWR were evaluated using species distribution analysis, ecogeographic diversity, and complementary analysis. A total of 20,125 occurrence records were used in the conservation gap analyses. Of the 102 priority CWR, 64 (62.7%) were conserved in the network of protected areas (PA), 56 taxa (55%), were conserved *ex situ*, while 43 of the accessions (76.7%) were underrepresented in *ex situ* facilities with less than 50 accessions. Complementarity analysis identified 29 reserve sites, 11 in the network of PA. 37 taxa (36.3%) of the priority CWR are passively conserved in the nine genetic reserve sites in the network of PA. The genetic reserve sites are aimed at augmenting the existing network of PA in the conservation of the priority CWR for sustainable utilization. A field survey should be conducted for the 38 taxa that did not occur in PA and a search for occurrence data for the 26 taxa without occurrence records and for those with less than 10 records in their countries of endemism. Also, *ex situ* collection of the 43 taxa with less than 50 accessions in genebanks should be prioritized. The establishment of the 29 identified reserve sites will further strengthen the CWR *in situ* conservation effort at the national and regional levels. Similarly, filling the identified *in situ* and *ex situ* conservation gaps will ensure that the priority CWR and agrobiodiversity are available for food, feed, and fiber. A global genepool conservation and use strategy for Dioscorea (Yam) was also developed in this study. Diversity and conservation gap analyses were carried out on the 27 priority yam CWR to determine the *in situ* and *ex situ* representativeness. 13 reserve sites were identified, with four located in the network of PA, 65.38 % are underrepresented *ex situ*, while 19.23 % are not represented in *ex situ* conservation. Eight yam priority CWR are passively conserved in the four genetic reserve sites in the network of PA. Four new genetic reserves should be established within PA in the four countries, (Sangha Trinational, Central Africa Republic; Socotra Archipelago, Yemen; Namtok Ched Sao Noi, Thailand; and Blue Fig Creek, Australia), to actively conserve the priority CWR. Also, germplasm collection of the five taxa not represented *ex situ* (*D. cirrhosa, D. inopinata, D. lanata, D. pynaertii* and *D. transversa*), 17 taxa underrepresented in genebanks should be prioritized. The impact of climate change on 63 West African priority CWR was analyzed using two climate change scenarios: socioeconomic pathway (SSP) 245 and 585 and two time points (2050 and 2070). The impact of climate change on West African CWR varied among the taxa, between the scenarios and the points. Seven CWR related to four crops were negatively affected by

climate change. *Vigna filicaulis* Hepper, a wild relative of cowpea was negatively affected by climate change across all the scenarios and periods. Predicted current taxa hotspots were found in the south of Ghana, south of Togo, south of Benin, and southwest Nigeria, while the predicted future taxa hotspots were found in Senegal, Gambia, north of Guinea, south and west of Mali, south of Burkina Faso, northwest of Ghana, north of the Benin Republic, northwest, and northeast Nigeria. The threat assessment conducted is aimed at identifying the threat categories of target taxa using the International Union for Conservation of Nature (IUCN) threat criteria. 24 priority CWR were threat assessed using the species information service of IUCN. Of the threat assessed CWR, 17 (70%) are Least Concern, 3 (12.5%) are Vulnerable, 1 (4.16%) is Endangered and 3 (12.5%) are Data Deficient. The 24 taxa were associated with 35 different habitats, with all the taxa occurring in at least two different habitats.

For Elizabeth, Nnanyere and Favour

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CHAPTER 1

INTRODUCTION

1.1 WHAT ARE CROP WILD RELATIVES

Crop wild relatives (CWR) are genetically related wild taxa of crops with trait diversity that can contribute to food security (Maxted *et al.*, 2006). CWR are unique sources of crop improvement through plant breeding. CWR are genetically diverse with resilient genes to adapt crops to marginal conditions and to meet the human need for ample food supply (Mercer *et al.*, 2007). The CWR of cultivated forms or weedy crops represents the primary gene pool (GP 1) in plant breeding. Those from which genes can be obtained with some challenges are categorised as secondary gene pool (GP 2), while in the tertiary gene pool (GP 3), gene transfer is relatively impracticable or may require advanced methods such as embryo rescue, somatic fusion, or genetic engineering (Harlan and de Wet, 1971; Maxted *et al.*, 2006; Magos Brehm *et al.*, 2017b). Additionally, where information on genus is lacking to determine the genepool level, usually for the purpose of crossing, the concept of taxon group has been proposed as follows; a crop wild relatives is a wild plant taxon that has an indirect use derived from its relative close genetic relationship to a crops; this relationship is defined in terms of the CWR belonging to Gene pool 1 to 3 or Taxon group 1 to 4 of the crop (Maxted *et al.*, 2006). In the taxon group (TG) concept, the crop is categorised as TG1A, TG1B denotes CWR of the same species as the related crop, CWR belonging to the same section as the related crop are classed as TG2, and CWR belonging to the same subgenus as the related crop is categorised as TG3, while CWR in the same genus as the related crop belongs to TG4 (Maxted *et al.*, 2006). During prioritization of CWR for active conservation, on the base of crop improvement, CWR are selected or given priority depending on the gene pool or taxon group they belong to and CWR belonging to the primary and secondary gene pool, as well as those in TG1 and TG2 are selected first as they are most closely related to the crop (Maxted and Kell, 2009).

CWR are the progenitors and congeners of their related crops which have been domesticated from them. CWR grow in the wild and are also found in lawns, roadsides, forests, farmlands, orchards, and wastelands. In their natural habitat and in the absence of anthropogenic disturbances, they produce adaptive features that enable them to thrive under harsh environmental condition and contribute valuable traits to crops. CWR have been used in the improvement of food crops, vegetables, fruits, tree crops, beverages and foliage (Vincent *et al.*, 2013). Nearly all cultivated crops are associated with one or more CWR. Farmers sometimes grow them close to crops to allow natural crossing of profitable traits to crops. The awareness of the value and use of CWR is gradually increasing. For instance, the number of publications reporting the use of CWR in crop improvement increased from 2% in 1970 to 38% after 1999 (FAO, 2009a). CWR also provide ecosystem services and contribute to a sustainable environment (Magos Brehm *et al.*, 2017b). The benefits derived from the ecosystem for the well-being of man are known as ecosystem services (IPBES, 2019). Ecosystem services include the provision of food, water, medicine, fertile soil, carbon sequestration, flood and erosion control (Aglanu, 2014). The plant diversity of a country or region usually determines amount of CWR in such area.

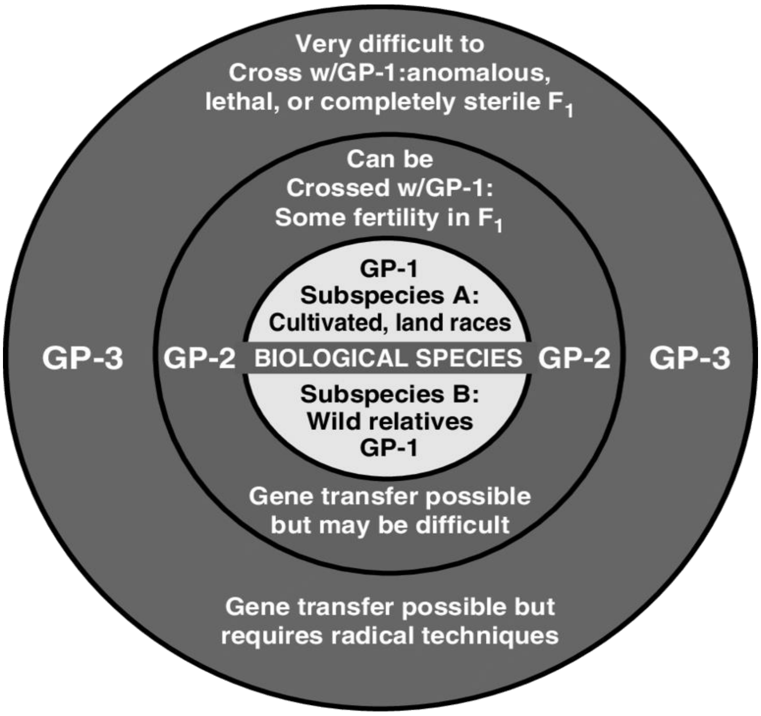

Fig 1.1: Gene pool concept (Harlan and de Wet, 1971)

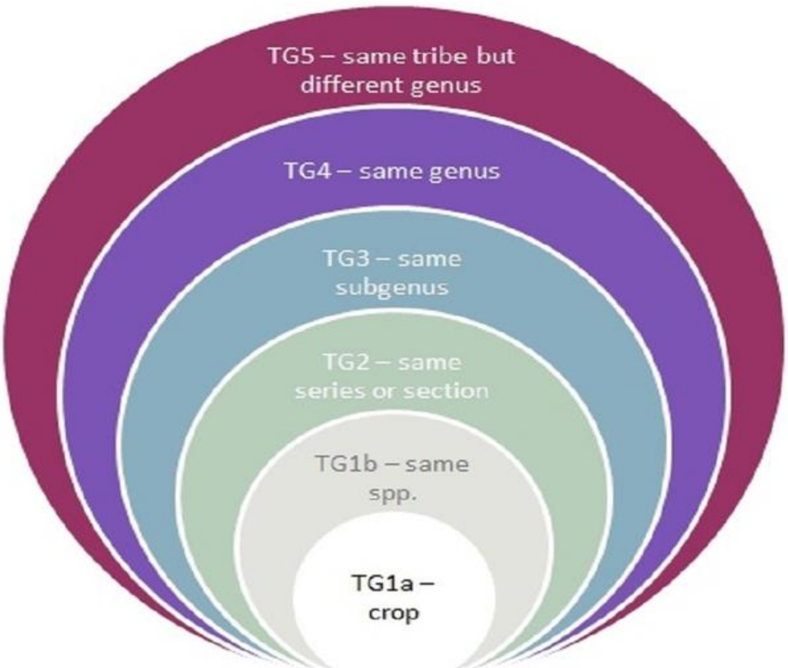

Fig 1.2: Taxon group concept (Maxted *et al.*, 2006; Magos Brehm *et al.*, 2017a)

The more plant diversity in an area, the greater the number of CWR in the area. CWR are still greatly untapped resources waiting for use in mitigating climate change and for crop improvement. CWR are resilient, hardy and are central to breeding activities because of their evolutionary relationship with cultivated crops (Khoury *et al.*, 2013). They have the potential to confers genetic materials and vital genes to domesticated crops and cultivars. In some parts of the world, CWR are harvested and consumed as sources of nutrients that are absent in conventional food crops. In such areas, CWR complement food crops in human dietary needs and enhance food provision. Globally, it is estimated that 50,000 to 60,000 CWR exist (FAO, 2009a) and constitute about 21% of the world flora (Maxted and Kell, 2009; FAO, 2017c). Similarly, Kell *et al.* (2008) that CWR constitute 85% of European flora.

Nikolai Ivanowich Vavilov (1887 – 1943) proposed the 'centre of origin' describing it as locations in the world where crops co – existed with their CWR. N. I. Vavilov was a Russian scientist who suggested that the centres of diversity could be used for crop improvement. Centres of diversity or 'regions of diversity' were the major locations where domestications occurred. Vavillov's work was based on the work of Alphonse de Candolle (1806 – 1893), who in 1882, published his work titled 'origin of cultivated plants' (de Candolle, 1882). Vavilov, during his exploration of the world, collated over 250,000 seed samples for conservation. Vavilov described crop domestication areas and identified those geographical locations where there are diversity of crop species and numerous CWR (Vavilov, 1992; Maxted and Vincent, 2021). In 1924, Vavilov suggested five 'centres of origin' which he revised into eight, namely; East Asia, Mediterranean, Central American, Hindustani, Inter -Asiatic, Caucasian, Abyssinian and Andean (Hummer and Hancock, 2015; Volk *et al.*, 2020). The revision of Vavilov's centres of origin was based on more information from his exploration and study of genetic diversity. P. M. Zhukovsky, an associate of Vavilov expanded Vavilov's centres of origin into 12 megacentres, including more centres such as Africa, Europe and Australia (Zhukovsky, 1965; Harlan, 1971; Maxted and Vincent, 2021). Harlan suggested three origins of agriculture as areas where agriculture evolved independently and non-centres, where domestication dispersed over radius of 5000 to 10000 km. The centres and respective non centres include Near East and a non-centre in Africa, North China centre with non-centre in Southeast Asia and South Pacific and Mesoamerica centre with non-centre in South America (Harlan, 1971; Maxted and Vincent, 2021).

1.2 THE NEED TO CONSERVE CWR

There is great need for the conservation and sustainable use of CWR nationally, regionally, and globally to ensure their existence and availability for crop improvement. CWR are sources of allelic variation for the development of crop varieties and cultivars. They are genetic resources for transferring valuable genes to crops. There is evidence of confirmed use of CWR in plant breeding. Many publications have reported several examples of the utilization of CWR in crop improvement (Fielder *et al.*, 2015). Examples include the transfer of trait a for resistance to *Cercospora* leaf spot and Rhizomania from wild sea beet (*Beta vulgaris* L. subsp. *maritima* (L.) Arcang) into the cultivated sugar beet (Lewellen *et al.*, 1987), introduction of the trait for resistance to leaf blight from wild *Tripsacum dactyloides* (L.) L. into maize (Goodman *et al.*, 1987). Also, grassy stunt virus resistance was transferred from wild rice (*0ryza nivara* D. S. Sharma & Shastry) to rice (Barclay, 2004), while cassava mosaic virus resistance was introduced from wild cassava (*Manihot glaziovii* Mull. Arg.) to cultivated cassava (Akano *et al.*, 2002). Maxted and Kell (2009) reviewed the use of CWR in crop improvement for 29 crops and the review shows that 234 references identified useful traits in 183 CWR. Also, the degree to which CWR are used in the improvement of crops, varies among crops (Magos Brehm *et al.*, 2017b). CWR have been used to improve several crops such as rice, wheat, potato, barley, cassava, banana, sorghum and wheat (Maxted *et al.*, 1997a; Atwell *et al.*, 2014; Blair *et al.*, 2016).

CWR have been overlooked because of the amount of money involved in their conservation and also, due to lack of understanding of their value. However, there is a growing interest in CWR conservation because of their use in crop improvement (Maxted *et al.*, 1997a; Heywood and Dulloo, 2005). The economic value of CWR is recently known by its monetary equivalent. For instance, Tyack and Dempewolf (2015) reported the findings of some studies that estimated the economic value of crop wild relatives in crop improvement to vary from USD 8 million to USD 165 billion (in 2012), for activities ranging from providing genes from wild tomatoes to contributing to the world economy. Recently, a study commissioned by Millennium Seed Bank (MSB), Kew, and performed by PricewaterhouseCooper (PwC), UK, showed that the CWR of 29 crops selected by MSB is valued at $42 billion, regarding their use in crop improvement. According to the report, the value may get up to $120 billion in the future (PwC, 2013). The current and future values were estimated at $68 billion and $196 billion respectively, if maize, sugarcane, and soya beans are included.

The importance of CWR conservation have been identified by international conventions and agreements, as well as the International Treaty on Plant Genetic Resources for Food and Agriculture (FAO, 2009b). They all emphasized the commitment of governments and relevant agencies responsible for the conservation and sustainable utilization of plant genetic resources. CWR were given precedence for preservation in the AICHI Biodiversity targets of its Global Strategy for Plant Conservation (CBD, 2015). They stressed the need to develop national strategic action plans for active conservation and sustainable utilization of plant genetic resources for food and agriculture (PGRFA). This will enhance the availability of CWR for crop improvement to attenuate hunger and ensure food and nutrient provision. Similarly, the second report on the status of the world's PGRFA (FAO, 2010), identified some shortcomings and the need for conservation and wise use of CWR and stressed the need to collect, document, and *in situ* conserve CWR that are already conserved *ex situ.* CWR have been included in the Sustainable Development Goal (SDG) of the United Nations (United Nations, 2015b). The United Nations Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Service, also, described CWR as plant diversity for future food security that would ameliorate the ecosystem and adapt crops to climate change (IPBES, 2019). The global strategy for plant conservation (GSPC) in its target 9 (CBD, 2010), requested that 70% of plant genetic diversity including CWR and other socio-economically valuable plant species be preserved by 2020 while conserving traditional and native knowledge. The importance of including more genetic resources in plant breeding programmes to avert genetic erosion resulted in the inclusion of CWR in the global collecting program of threatened plant genetic resources, carried out by the International Board for Plant Genetic Resources (IBPGR), where 220,000 plant samples were collected in over 130 countries of the world during decades, which ended before 1995 (Thormann and Engels, 2015; Thormann *et al.*, 2015). Recently, a program of CWR collection known as 'Adapting Agriculture to Climate Change' coordinated by the Crop Trust, which concentrated on CWR of 29 cultivated crops in Annex 1 of the International Treaty for Plant Genetic Resources, collected 4500 CWR for *ex- situ* conservation and appraised for vital genes in plant breeding (Dempewolf *et al.*, 2014; Engels and Thormann, 2020).

A strategic and consolidated approach is required in *in situ* and *ex situ* techniques of CWR conservation. The application of *in situ* and *ex situ* methods in conserving CWR differs, depending on the taxa under consideration for conservation, available resources, and the utilization of the taxa. *In situ* conservation involves the identification, selection, active management and monitoring of the selected plant population within their natural habitat or where they have developed their distinctive characteristics (Maxted *et al.*, 1997c). Whether formally or informally designed, *in situ* conservation of CWR is often done in safeguarded places and conservation can target either the entire ecosystem where they reside or the population itself (Nilsen *et al.*, 2017). The location designated for active *in situ* conservation is properly managed with regular monitoring of the target taxa, usually for a long period (Maxted *et al.*, 2008b). *In situ* conservation has been considered as the major conservation method while *ex situ* technique is complementary. As opposed to the *ex situ* approach, *in situ* conservation enhances the innate interchange of genetic materials and the evolutionary relationship between crop wild relatives and their related crops (Maxted *et al.*, 1997a; FAO, 2001; Magos Brehm *et al.*, 2017b). There is usually a change between the identification of suitable sites for *in situ* conservation of CWR and the actual implementation and management of the proposed sites. Resolving this will bring together, the research community that identified the target CWR and selected sites with the site managers that will manage the protected areas where the CWR will be conserved (Meilleur and Hodgkin, 2004; Magos Brehm *et al.*, 2017b).

The *ex situ* conservation approach, involves the location, sampling, and movement of plant genetic resources to a suitable site for preservation away from their natural environment (Maxted *et al.*, 1997c). Several *ex situ* methods exist, however, seed storage in genebanks is mostly used in *ex situ* conservation of different taxa. Other methods of *ex situ* conservation of plant materials are in living plants, *in vitro* explants conservation or cryopreservation. A coordinated and comprehensive effort is required in stewardship of CWR, to avoid genetic erosion. Genetic erosion will result in the reduction in the short- and long-term fitness of individuals, population as well as decline in evolutionary potential of species and populations. It would also lead to decline in the availability of novel genes and allelic variations, limiting the choice of breeders for the development of resilient cultivars, which will further impact negatively on global food security (Magos Brehm *et al.*, 2017b). On some occasions, crop production is carried out in adverse environment which affects output negatively. Therefore, CWR should be conserved due to the demand for food, and the novel traits for better crop yield that is contained in them. Recently, biotechnological approaches and traditional breeding methods have improved greatly, allowing the identification and isolation of specific genes of interest and in their introduction to crops (Magos Brehm *et al.*, 2017b). CWR also contain medicinal properties and have been used to increase medicinal traits in plants. For instance, a gene for anticancer chemical constituents have been transferred from wild *Brassica oleracea* L. to broccoli (Hodgkin and Hajjar, 2007).

1.3 THREAT STATUS OF CWR

Globally, the genetic diversity of CWR are threatened like other wild plant species (Engels and Thormann, 2020). Unsustainable use of natural resources, climate change, urbanization, population growth (Amri *et al.*, 2008), natural disaster, introduction of alien species (Mounce *et al.*, 2017) are some of the major threats to CWR conservation. About 35% selected Mesoamerican CWR and over 70% of the world most important crops are at the verge of extinction (Goettsch *et al.*, 2021). FAO reported that an estimated 75% of genetic diversity of cultivated crops have been lost because of neglect of genetically diverse native crops. Some important CWR are found in few areas with small number of populations. For instance, a CWR of maize, *Zea nicaraguensis* Iltis & B. F. Benz is confined to one protected area in Nicaragua, while *Helianthus paradoxus* Heiser, a CWR of sunflower exist only in few small locations in USA (Board of Trustees RBG Kew, 2021). Genetic erosion is also critical challenge to the conservation of CWR in nature. Genetic erosion leads to decline in species richness and reduces the sum of alleles in a population. Genetic erosion can occur due to anthropogenic disturbances and marginal environment (Thormann and Engels, 2015; Herden *et al.*, 2020). It is the loss of genetic diversity within species and can occur quickly or over a long period. Genetic erosion can occur as a loss of a whole population that differs genetically or a loss of a variety of genes present in a population. Genetic erosion is a threat to the use of CWR for plant breeding. Part of the genetic erosion found in the field has been augmented by *ex situ* conservation in genebanks (FAO, 2010). However, genebanks have concentrated more on the collection and preservation of major crops, while only 2% of non-staple crops are not conserved. Similarly, CWR are not well represented in genebanks (Castañeda-Álvarez *et al.*, 2016). The uniqueness of CWR is in the diversity of genes contained in them, and when this abundance of the various genes is lost, it reduces the usefulness of CWR in crop improvement (Bioversity International, 2021).

Lack of conservation action is a threat to CWR diversity. Many CWR are found in marginal habitats, field borders, and forest margins, and these species are not actively managed by relevant authorities and institutions. There is a lack of interest in the conservation of CWR, leading to its neglect. Inventories are lacking in many countries, and the conserved CWR are not identified and appraised (FAO, 2010) Sometimes, funds remitted for the conservation of CWR are not judiciously used for the purpose. Governments and relevant authorities need to facilitate the designation and establishment of more protected areas, reservoirs and sanctuaries for CWR conservation (Maxted *et al.*, 2008a; Magos Brehm *et al.*, 2017b). Existing protected areas should be rehabilitated and maintained for active *in – situ* conservation action. Capacity building and hands – on training need to be regularly organized for protected area managers and personnel, while more personnel should be involved in the conservation process. Genebanks and *ex situ* conservation facilities need to be established to complement *in situ* conservation method. Stakeholders, such as the research communities, protected area managers, genebank curators, farmers, breeders, relevant government authorities and institutions should synergistically ensure the active conservation and sustainable utilization of CWR (Khoury *et al.*, 2009; Maxted and Kell, 2009).

CWR need to undergo regular threat assessment to determine their population size and status and distribution. For CWR that have not been IUCN Red List evaluated at all and for those with assessments that are not reviewed, threat assessment is urgently needed. Threat status of CWR is required in the prioritization process of CWR conservation action plans. When the assessment status of CWR is lacking, it will involve the collation of large dataset to help in the implementation of the conservation action. Also, these distributional data can be used in threat assessment of the CWR. Threat assessment can be carried out simultaneously with the planning and implementation of conservation action, and then used in prioritization to further strengthen the conservation action plan (Magos Brehm *et al.*, 2017b). For the evaluation of species threat status, The IUCN Red List Category and Criteria (IUCN, 2012a), has been used, globally. They have been used to show transparency and impartiality in the evaluation of species and therefore ensure consistency among users. The categories and criteria are used to determine the level of threat for plant species, globally (IUCN, 2012b). Significant improvement has been recorded in the appraisal of CWR, for areas with known flora. Though CWR are at the risk of diversity loss and extinction, they are less threatened, relative to other wild species (Stolton *et al.*, 2006; Kioukis *et al.*, 2020).

Recently, about 54% of 1,155 monocotyledonous plants assessed in IUCN 2008 were categorized as endangered in the wild, while 12% were indicated as critically endangered. These monocots supply over 50% of the global human food energy need and include important crops like rice, wheat, maize, barley and sugarcane (Bioversity International, 2021). Similarly, an IUCN Red List assessment of 224 Mesoamerican CWR related to nine crop genepools were done by Tobón-Niedfeldt *et al.* (2022) the outcome showed that 35% of the taxa are threatened with extinction, seven are CR, 47 are EN, 16 are VU, while nine are NT. Also, an IUCN Red List assessment of 591 European CWR belonging to 25 crop groups was carried out, the result indicated that 66 (11.5%) are Threatened, 19 (3.3%) are Critically Endangered, 22 (4.4%) are Endangered, while 26 (4.5%) were categorized as Near Threatened. Apparently, within the threatened categories, only 11.5% of the CWR are threatened, remarkably lower than the 40% overall figure for all plant species (United Nations, 2014), but this might be explained by their resilience to anthropogenic disturbed habitat (Kell *et al.*, 2012).

1.4 CLIMATE CHANGE EFFECTS ON CWR AND AGRICULURE

It is expected that the effect of climate change will adversely affect CWR in the future (Phillips *et al.*, 2017). These unpredictable changes will increase the prevalence of pests and diseases and affect cropping systems (Schneider *et al.*, 2022; Rahman *et al.*, 2023) A study on the expected effect of climate change on the genepool of three CWR was carried out (Jarvis *et al.*, 2008), and it was projected that by 2055, 16 to 22% of CWR would become extinct and most of the species will lose half of their habitats, while the remaining habitats would be fragmented. Climate change will likely determine the distribution of CWR (Cobben *et al.*, 2013) and adversely impact on future food and nutrient provision (United Nations, 2014). Reports from different countries of the world, indicate negative impact of climate change on plants (Khoury *et al.*, 2009). The prediction by the International Panel on Climate Change (IPCC, 2013), shows unfavourable impact of climate change on the availability of CWR, globally. Khoury *et al.* (2009) projected the effect of change in climate on areas fertile for several major crops, using current and predicted data for 2055. The outcome indicated a loss of agricultural areas including different parts of Sub-Saharan Africa. Another report indicated a related effect in Sub-Saharan Africa, with a significant loss of suitable land for the cereal cultivation (Ortiz *et al.*, 2010). However, an increase in suitable land will occur in some advanced countries further from the equinoctial line of the latitude. However, those areas of the world with large populations of the poor such as Southern Africa and South Asia are prone to the adverse effects of climate change (Xiong *et* *al.*, 2010). To adapt crops to climate variation needs the use of cultivars with more tolerance to heat and drought for optimum harvest. Changes in pest and disease patterns may happen, leading to the need for tolerant crop varieties (Fita *et al.*, 2015). The challenge of crops thriving under adverse environmental conditions will increase the difficulty to provide food in the future (Islam and Karim, 2019).

Climate change will adversely affect agricultural productivity in different countries of the world (GCDT, 2008). Agriculture is the most weather-dependent human activity with its focus on food production and will be negatively impacted by climate variability (Hansen, 2002). The continent that is more liable to suffer from the negative impact of climate change is Africa since an estimated 75% of Africa relies on Agriculture (United Nations, 2014), while farmers in the region depend on rainfall to grow crops. It has been projected that by 2050, maize may be scarce in Southern Africa (Gemeda and Sima, 2015). The West African region is specifically susceptible to climate change, due to lack of institutional capacity to manage and adapt to variable climate and subsistent approach to farming. Also, considering the relationship between climate change and farming, the region becomes a hotspot for current and future climate change (Dingkuhn *et al.*, 2006). Similarly, several food insecure, poorer nations will be at the risk of the disruptive impact of climate change (Jarvis *et al.*, 2008). For agriculture to play a part in attenuating the effect of climate change, novel cultivars will be needed. If new cultivars that are resilient to climate variation are provided, some regions will have a protracted cropping season and will become more productive, especially those away from the equatorial line of the latitude. Selecting the climate change adaptive crop varieties and the use of eco- friendly agricultural practices are vital in mitigating the impact of climate change to ensure food availability (Roudier *et al.*, 2016).

Recently, there is a growing concern over the impact of climate change on the yield of crops. A study showed the trend of effect of climate change on the yield of crops from 1980 to 2008. It was reported that there was a yield decline of over 5% in corn, wheat and soyabean (Lobell *et al.*, 2011). It was reported that under different emissions, there was a significant reduction in the yield of wheat, sunflower and cotton. Some crops are more affected by climate variation than others due to the degree of temperature rise in the area (Lobell *et al.*, 2011; Shepard, 2018). Climate change is reducing the food calories of ten major food crops by 1% per annum. This amount of calories can provide a daily dietary need of more than 1800 calories for over 50 million people (Ray, 2019). Wheat, rice, maize and soybean supply two third of human calorie need (Zhang *et al.*, 2017). The global yield of wheat and maize is expected reduced by 6% and 7.4% respectively, for each degree – Celsius rise in global mean temperature (Zhang *et al.*, 2017). The global mean temperature is expected to rise by 2º C in 2042 and up to 4º C between 2075 and 2132. Tigchelaar *et al.* (2018) reported that the yield of corn will decline by 40% in most parts of the world at 2ºC rise in temperature. Imbach *et al.* (2017) reported that the suitable areas for coffee production will decrease by 73 – 88% by mid-century due to climate change. Climate change threatens coffee species and specifically, a species that accounts for about 20 to 25% of coffee production. A study by ICTA (2011) shows that farmers will experience a significant decline in cocoa production by 2030 due to climate change. Cocoa is one of the important cash crops in West Africa and a major raw material for producing chocolate. Over 50% of global chocolate is sourced from West Africa; mainly Ghana and Cote D' Ivoire. Cocoa growing areas located within 300 km from the coast may shrink and this development will affect most farmers that practice monocropping using cocoa. Similarly, Wolkovich *et al.* (2018) reported a potential decline in wine production of about 85% over the next five decades because some wine-producing regions of the world will become too hot to produce wine. Climate change accounts for more than 60% yield decline in world breadbasket (Ray *et al.*, 2015).

Greenhouse gases from anthropogenic activities are the major cause of climate change (IPCC, 2013). Jägermeyr *et al.* (2021) reported that if greenhouse gas (GHG) emission is not controlled, climate change may lead to a yield loss of 24% and 17% in maize and wheat respectively, by 2030. Similarly, according to Johnston (2017) if there is no remarkable reduction in emissions, the yield of soybean crops could decline by 40% by 2100. From 1990 to 2015, the global emission of greenhouse gases increased by 43%. Within this time, CO_2 increased by 51% (EPA, 2021). The amount of CO_2; one of the major greenhouse gases is at the highest amount. Another greenhouse gas, methane constitutes approximately 16% of total greenhouse gas release (Nunez, 2019). Schlenker and Roberts (2009) reported a decline in crop yield with an exponential rise in temperature. The yield of wheat and corn has decreased by 4 – 8% since 1980 compared to the expected yield without a temperature rise (Lobell *et al.*, 2011a). Within the same period, there is a reduction in the yield of cereal crop for every 1º C in temperature (Lobell *et al.*, 2011b). The total GHG emission from West Africa in 2014 was 994.70 million metric tons of carbon -dioxide equivalent, about 2.03 % of global GHG emissions. Over 30% of the GHG emission was from land-use change, 27% from energy, while agriculture was responsible for 23%. Waste and industrial processes accounted for 11% and 8% respectively (FAOSTAT, 2018a; USAID, 2019). West Africa with 5.26% of the world population, emits 1.08 metric tons per capita of carbon-dioxide equivalent (tCO_2e) is about six times below the world average. 50% of the total GHG emission came from Nigeria, with Liberia, Guinea–Bissau, and Cape-Verde emitting less than 1%, each of the total emissions. Between 1990 and 2014, the West African total GHG emissions increased by 17% (USAID, 2019).

The evolving climate change will result in the growing need for cultivars that are resilient to environmental change with more viable seed systems. It is important that plant breeding efforts are intensified globally, especially, in those countries that are prone to the negative effects of climate change. This will involve modern plant breeding methods and training in the best use of traditional techniques (Raza *et al.*, 2019). Increased access to genetic diversity is needed in the breeding of new varieties and cultivars as it will ameliorate the impact of climate change (Arnell and Gosling, 2016). Some underutilized crops may become important as some major crops may become scares. *In situ* conservation will be important in the future because of its efficiency in conserving CWR diversity (Maxted and Kell, 2009). It would be relevant to identify and appraise much germplasm collections for disease resistance; tolerance to drought, heat, soil salinity and waterlogging (Chivenge *et al.*, 2015). Dynamic plant breeding methods through the transfer of resilient genes from CWR to crop should be introduced to mitigate the disruptive impact of the marginal environments on crop production. While the effect of climate change is unfolding, there is the awareness that the future impact will be severe unless urgent measures are taken (Cobb *et al.*, 2019). *Ex situ* conservation will become a major approach to the preservation of species threatened by climate change. Also, collections in genebank facilities will be central in the breeding of new varieties resilient to climate variation (GCDT, 2009). The utilization of CWR under the impact of climate change will lead to the selection of CWR species that can withstand climate change as well as contribute valuable genes for crop improvement (Jarvis *et al.*, 2008)

Deforestation is a major cause of climate change. Trees have a cooling effect on the environment and can mitigate the effects of climate change. Transpiration from trees adds moisture to the atmosphere, while deforestation makes the atmosphere warm (Seymour, 2018). Globally, the rate of deforestation is increasing exponentially and accounts for about 10% of GHG emission (Mufson, 2019). About 40 football fields of forest were lost each minute in 2017 due to the growing demand for timber, palm oil, cocoa, rubber, and other woody products of the forest. The rate of deforestation in Nigeria from 1990 to 2014 ranged from 2% to 5% per annum (FAOSTAT, 2018b), 4 to 10 times the Western and Central Africa region's annual deforestation rate of 0.46%, for the same period of 1990 to 2010. As of 2014, the total forest area in Nigeria is 7.4 million hectares or 8% of the country's total land mass (Federal Republic of Nigeria, 2018). In Ghana, the area where trees have been cut is equivalent to the size of New Jersey in the USA (Cocoa and Forest Initiative, 2020). About 80% of Cote D' Ivoire forests have been lost over the last five decades (Morisset, 2018).

1.5 CWR AND GLOBAL FOOD SECURITY

There is food security when at all times, everyone has economic and physical ample access to safe, satisfactory, and healthy food to meet their dietary requirement and choice of food for a productive life (Rogers *et al.*, 2009). More than 820 million people are living in hunger, while over 2 billion lack adequate nutrients (FAO, 2017a; Ingram, 2020). Modern techniques and knowledge based on biodiversity and traditional flora should be used in agricultural practices, while the growth of crops that are resilient to climate change should be included in the frameworks of food provision (FAO, 2017c). CWR are used in crop improvement to ensure food and nutrient provision for the rural and urban populations (FAO, 2018). More attention should be given to policies that conserve indigenous diversity to promote high–quality and healthy food for all.

There is a gap between the quantity of food produced now and that needed to feed the world in the mid-century (Berners-Lee *et al.*, 2018; Ranganathan *et al.*, 2018). To meet the food needs of the burgeoning global population that is projected to reach 9.7 billion in mid-century, food production must be increased in the next decade (Food and Agriculture Organisation of the United Nations, 2009). Another billion tonnes of cereal are needed annually up until 2050 to feed the world (Swiderska, 2009). Van der Mensbruggh (2009) that to feed the growing world population, agricultural production must increase at the average rate of 0.8% per annum. As projected by United Nations (2011), the global population is expected to rise by 35% from 6.9 billion in 2010 to 9.3 billion in 2050. Alexandratos and Bruinsma (2012) and Kastner *et al.* (2012)Kastner *et al.* (2012) opined that the global food demand may rise from 60 to 120 % by 2050. Three crops; wheat, maize, and rice supply over 50% of global plant-derived calories (Gibbon, 2012). However, the demand for these three crops is projected to rise by 33% by 2050 (FAO, 2013). Between now and mid-century, the demand for maize in developing countries will double (Rosegrant *et al.*, 2009). Globally, only about 55% of edible crop calories are consumed directly by humans, 36% is used to feed animals, while the remaining is used for biofuel production and other industrial purposes (Cassidy *et al.*, 2013). About 7% of 1.4 billion hectares of crops were used for biofuel production in 2020 (Biofuel International, 2022). Ensuring food provision is one of the 17 Sustainable Development Goals of the United Nations as contained in its 2030 sustainable development program (United Nations, 2015a). Despite the existence of about 300,000 angiosperm plant species, humans rely on less than 12 crops for 80% of their caloric intake (McCouch *et al.*, 2013).

Food provision is still a challenge to many countries of the world. An estimated 1.2 billion people live in Africa. It is projected that more than half of the population of the world growth between now and 2050 will occur in Africa (UN-WPP, 2015). The highest number of undernourishment is recorded in Africa with more than 256 million, about 20.4% of the world, with the largest in West Africa and the least in Eastern Africa (Islam and Karim, 2019). There is a correlation between an increase in population number and demand for food. CWR are potential resources for breeding crops to meet the global food need. The novel traits can be used to develop high–yielding cultivars to mitigate the growing challenge of food availability. With the use of effective breeding programmes, together with institutional and technical support, food production can be improved by up to 70% in 2050. This can be achieved by introducing resilient CWR into the breeding program (UN-WPP, 2015).

Reports from different parts of the world depict the importance of plant genetic resource conservation in augmenting food availability. Recently, the rate of crop production gives reason for concern. In Africa, the yield and output of some major crops such as wheat, rice, and maize are lower than that from other parts of the world. For most countries, cultivation of staple food crops remains the largest agricultural subsector and will continue to play a leading role in meeting the need of food security and the developmental objective of agriculture in the future (Reyolds *et al.*, 2015). Maintaining increasing crop production in areas where high-yielding, adaptive cultivars and good agronomical practices have been significantly used, will be an essential approach for ensuring food availability in the future. It will require some resilient varieties to adapt to the variable climate (Rockström *et al.*, 2017).

1.6 AGRODIVERSITY AND CWR

Agricultural diversity includes all species and their genetic diversity that is relevant to agriculture. It comprises all components of biological diversity relevant to food and agriculture. At the genera level, agrodiversity includes all the cultivars, species, varieties, landraces, and wild relatives of the same crop. It is the bedrock of human existence and health (Mburu *et al.*, 2016). The preservation of agricultural diversity is pivotal in achieving the goal of securing a safe and healthy food system. Usually, a home garden anywhere around the world comprises about 20 to 50 different plant species (Eyzaguirre *et al.*, 2004). Conventional agriculture makes use of fertilizers and pesticides which cause pollution, greenhouse emissions, and other negative impacts on the environment. Managing agrodiversity ensures the perpetuation of developmental processes leading to the availability of choices in crop production. This diversity and varieties of crops help to mitigate climate change and control pests and diseases (Mburu *et al.*, 2016). Agrodiversity is important in maintaining the essential roles of the ecosystems (Segnon and Achigan-Dako, 2014). Each plant species has a role in nature and agricultural productivity relies on crop diversification (Bongers *et al.*, 2015). Agrodiversity can be used by smallholder farmers to manage the risk of drought, pests, and disease through the growing of different crop varieties. Some Indigenous crop species, native fruits, and medicinal plants can be commercialized to improve the livelihood of smallholder farmers (Enjalbert *et al.*, 2011). Agrodiversity also enhances water supply, fertile soil, and structural ecosystems. The continent of Africa is enriched with great agrodiversity, which is present in dietary diversity and can be used to enhance the nutrient level and food security in the region (Mburu *et al.*, 2016).

Conservation of agrodiversity is essential for its derived benefit, to sustain our biological heritage, and to ensure its continual existence (USAID, 2022). Effective conservation, monitoring, and utilization of agrodiversity depends on information on availability, location, threat status, distribution, conservation status of the diversity, what site is suitable for effective conservation of the diversity, method of conservation, and presence of traits of interest (Bioversity International, 2017). Such information will help farmers, scientists, relevant authorities, and institutions to make informed decisions on what agrodiversity to conserve, the location to conserve it, and the method of conservation. Though there are data sources documenting *ex situ* collections of agrodiversity at the global level. There is no documentation on *in situ* diversity at the global or national levels, except for FAO monitoring on the compliance of the second Global Plan of Action on Plant Genetic Resources for Food and Agriculture (Bioversity International, 2017).

The conventional intensive farming system appears to be a major threat to agrodiversity (Phalan *et al.*, 2011). An alternative farming system is required to increase and improve agricultural productivity. Such method of farming should be sustainable, increasing soil organic matter, yield improvement, and resistance to pests and diseases (IAASTD, 2009). There should be implementation of enhanced techniques for sustainability in the agricultural sector, to achieve global food security (IFAD/UNEP, 2013). Intensification that uses external input may be used to ensure food security. However, the use of CWR as an alternative approach to agricultural intensification will make the most productive use of available genetic resources (Renzi *et al.*, 2022). Sustainable agroecosystems are those with a positive impact on humans and the environment (Prettey and Bharucha, 2014). To produce more food, fiber and fuel, while using less land, energy, and other inputs, CWR is needed in crop improvement for sustainable intensification and guaranteeing resource efficiency in farming (Dempewolf *et al.*, 2014).

Intensive farming is one of the causes of agrodiversity loss, resulting in the loss of a large number of plant species and cultivars and affecting the effectiveness and services of the ecosystem over the years (Emmerson *et al.*, 2016). Farmers should be aware of the impact of their practices on agrodiversity to ensure its continual existence for use. Ecosystem managers and farmers can leverage the services and benefits provided by agrodiversity for sustainable agricultural productivity (Lipton, 2012). This can be achieved through an eco-friendly farming systems that may include on-farm and *ex – situ* conservation of valuable crop genetic diversity for increased yield and a sustainable environment (Roberts and Mattoo, 2018). Currently, there are no effective laws guiding local farmers to preserve the agrodiversity on–farms. Organic farming through the use of organic inputs can also increase crop yield and impact positively on the environment (Tal, 2018). Sustainable intensification offers healthy and nutritious food using minimal input, with this method, the present generation can reach their food needs without compromising the food security of the future generation (McKenzie and Williams, 2015).

1.7 AGRICULTURE AND FLORISTIC DIVERSITY OF WEST AFRICA

Agriculture in West Africa ranges from nomadic farming in some parts of the north to cultivation of root and tree crops in the south. Millet and sorghum are the major cultivated crops in the Sahel part of the region, while maize, groundnut, and cowpea are the predominant crops grown in the south (USGS, 2017). These crops are grown mostly in West African countries including Burkina Faso, Mali, Mauritania, Niger and Senegal. Root and tuber crops such as yam and cassava are grown in West Africa such as Cote D' Ivoire, Ghana, Nigeria, and Sierra Leone. Other crops like cocoa, rice, and oil palm are grown in Guinea and Liberia. Agricultural land covers about 22.4% of West African land mass and constitutes about 35% of the Gross Domestic Product (GDP) of West Africa, employing 60% of the active workforce (Jalloh *et al.*, 2013). Nigeria has the highest expanse of land for agricultural activities in West Africa, with agriculture accounting for 41.5% of the country's land mass. In Burkina Faso and Togo, agricultural land accounts for 39% and 34% respectively of the countries' land mass. The economy of Mali relies on the resources obtained mainly from agriculture (USGS, 2017). The disproportionate correlation between employment rate and GDP shows that most West Africans are poor (Jalloh *et al.*, 2013). The lack of modern technology, lack of agricultural inputs, and incentives for farmers, limits agricultural development in the region (Ola and Benjamin, 2019). In some West African countries, farming is usually done on small plots of land due to the large population of the region, leading to scarcity of land. Intercropping is a primeval and extensively used agricultural system in West Africa (Mason *et al.*, 2014). It involves growing two or more crops together on the same piece of land in the same growing season (Bright *et al.*, 2017), to maximize yield, control weeds, retain soil fertility, reduce labour costs, and prudent use of land (Haglund *et al.*, 2011). Intercropping is usually used in cereals such as millet, maize, or sorghum with legumes such as cowpea and groundnut (Kermah *et al.*, 2017). Similarly, intercropping between legumes and root or tuber crops such as yam and cassava has been reported (Kouelo *et al.*, 2014).

The West African ecosystem is diverse with forests including the Guinean forest, designated as one of the 36 biodiversity hotspots in the world (USAID, 2022). The various ecosystems in West Africa range from dry savannah to tropical rainforest (USGS, 2017). The lowland forests of the region are the habitat of over 9000 vascular plants, while 1800 species of the plants are endemic to West Africa (Carr *et al.*, 2015). West African forests are largely threatened by urbanization, hunting, logging, climate change, grazing, poverty, and overpopulation (Aglanu, 2014; Ola and Benjamin, 2019). Also, the existence of invasive species, pesticides, over-exploitation of natural resources, and illegal land use practices are threats to the floristic diversity of the region (Carr *et al.*, 2015). Nix (2019) that 90% of the West African original forest has been lost, while the remaining is fragmented and degraded. About 483 West African plant species are at risk of extinction (Carr *et al.*, 2015). This has resulted in the confinement of threatened plant species to various protected areas. An estimated 1,936 national protected areas are present in West Africa, constituting about 9.6% of the region's land mass (USGS, 2017). The various forests in West Africa contains economic trees and plants that generate ecosystem services and products such as timber, fruits, fibre, food, and fibre to support the livelihood of the population (Ola and Benjamin, 2019). Some native tree species in West African forests are *Khaya spp*. (African mahogany), *Milicia excelsa* (Iroko), *Pentaclethra macrophylla* (Oil bean tree), *Terminalia superba* (Afara), *Lovoa trichilloides* (Bibolo), *Entandrophragma spp.* (Sapele), *Treculia africana* (African breadfruit) and *Dacryodes edulis* (African plum), etc. Climber plant species include *Adenia lobata, Dioscorea preussii, Diocorreophyllum comminsii, Gounia longipetala, Montandra guineensis and Parquetina nigrescenns* (ITTO, 2002). The West African countries include Burkina Faso, Benin, Cote D' Ivoire, Cape Verde, Ghana, Gambia, Guinea, Guinea – Bissau, Liberia, Mauritania, Mali, Nigeria, Niger, Sierra Leone, Senegal, and Togo.

1.8 RESEARCH OBJECTIVES

This study aims to investigate CWR diversity in West Africa as a basis for improved conservation and use of these natural resources to promote food and nutritional security and improve livelihood benefits for farmers in the region.

This broad aim includes several specific objectives to

1. Produce a prioritized inventory of CWR that requires conservation action in West Africa
2. IUCN Red List threat assessment of priority CWR found in West Africa
3. Climate change modeling of priority CWR in West Africa
4. Develop a regional CWR conservation strategy for West Africa
5. Propose a global genepool conservation strategy for *Dioscorea* (Yams) to promote food and nutrient security and improve livelihood benefits for smallholder farmers in the region.

CHAPTER 2

WEST AFRICAN CROP WILD RELATIVE CHECKLIST, PRIORITIZATION, AND INVENTORY

The work presented in this chapter has been published in Genetic Resources

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2.1 ABSTRACT

Crop wild relatives (CWR) are wild plant taxa genetically related to domesticated crops with trait diversity that can be used in plant breeding to sustain food security. Prioritization is a prerequisite for the cost – effective conservation of CWR as it allows CWR in a checklist to be reduced to a manageable number for active conservation action. In this study, a partial CWR checklist comprising 1651 taxa was compiled for West Africa. Prioritization of the annotated CWR checklist was based on three criteria: (i) economic value of the related crop in West Africa (ii) CWR genetic closeness to its related crop and (iii) threat status. After applying the three criteria using the parallel method of prioritization, 102 priority CWR were selected for active conservation action. The priority CWR are related to food crops that are nationally, regionally, and globally important, such as white guinea yam (*Dioscorea cayenensis* subsp. *rotundata* (Poir) J. Miege, cassava (*Manihot esculenta* Crantz), rice (*Oryza sativa* L.), wheat (*Triticum aestivum* L.), cowpea (*Vigna unguiculata* (Linn.) Walp.), sweet potato (*Ipomea batatas* (L.) Lam), common bean (*Phaseolus vulgaris* Linn.) and sorghum (*Sorghum* bicolor (L) Moech). This CWR checklist and prioritization will help in the development of a regional conservation action plan for West Africa.

Keywords:

Crop wild relative, checklist, prioritization, inventory, crop improvement, conservation.

2.2 INTRODUCTION

The significant effects of climate change on agriculture and livelihood in West Africa recently show the need to develop varieties of crops that can adapt to the rising temperatures, desertification, unpredictable rainfalls, floods and droughts and new diseases and pests, as well as meet the yield quality and quantity requirements of producers and consumers (Maxted *et al.*, 2015; Mousavi-Derazmahalleh *et al.*, 2018; Allen *et al.*, 2019). Climate change has led to yield losses in different crops and will continue to adversely affect agriculture with considerable yield decline predicted in West Africa (Sultan *et al.*, 2019). IPCC reported that the duration of the growing season in West Africa may be reduced by 20% in 2050, resulting in about 40% yield reduction in cereals (Zougmoré *et al.*, 2016). The increasing population in the Western Africa region may further limit the ability of the region to meet the food and nutrient security needs of its growing population. CWR are wild plant taxa genetically related to domesticated crops and are widely recognised as a major reservoir of valuable diversity that can be used in plant breeding to sustain food and nutrient security in the future (Maxted *et al.*, 2006; Magos Brehm *et al.*, 2017b; Herden *et al.*, 2020). Many CWR thrive in marginal environments (Jarvis *et al.*, 2015; Phillips *et al.*, 2017; Vincent *et al.*, 2019), making them better suited to withstand changing climate conditions. The extensive genetic diversity in CWR has been used globally in plant breeding programmes to produce crop cultivars with traits for high yield, drought tolerance, disease resistance, good handling quality, seed weight, early flowering time, cooking quality and better storage quality (Maxted and Kell, 2009; USDA, 2011).

CWR conservation and use contributes to the Sustainable Development Goal (SDG) of the United Nations (United Nations, 2015a). Also, the United Nations' Intergovernmental Science – Policy Platform on Biodiversity and Ecosystem Service (IPBES), described CWR as vital for future food and nutrient security, ameliorating ecosystems and adapting crops to marginal environments (IPBES, 2019).

There are about 45,000 plant species in Sub-Saharan Africa (Linder, 2014). In Nigeria alone, there are thought to be 7,895 different plant species (Federal Republic of Nigeria, 2010). However, the diversity of CWR is widely threatened by unsustainable use of natural resources, urbanization, deteriorating environmental conditions, the introduction of exotic species and climate change (Maxted and Kell, 2009; Magos Brehm *et al.*, 2017b). Several CWR thrive on farmlands and are therefore threatened by agrochemical inputs and intensive agricultural systems (Jarvis *et al.*, 2015; Capistrano-Gossmann *et al.*, 2017; Vincent *et al.*, 2019). Also increasing population, poverty, habitat destruction, overgrazing, lack of land use planning and deforestation causes biodiversity loss in West Africa (Adejuwon, 2000). There is therefore the need for active *in situ* and *ex situ* conservation of CWR in West Africa, to ensure they continue to provide profitable genes to produce plant cultivars to meet the growing demand for ample food supply for the people of West Africa and beyond.

Developing a regional and national conservation plan is essential if poverty alleviation and food provision is to be maximised. This starts with making an inventory of CWR. Several countries already have CWR inventory, such as UK (Fielder *et al.*, 2012), USA (Khoury *et al.*, 2013), China (Kell *et al.*, 2015) and Indonesia (Rahman *et al.*, 2019). A CWR checklist is a list of CWR taxa found in a defined geographical area (Maxted *et al.*, 1997a). A CWR checklist may contain additional information on the priority CWR which are important for conservation planning including taxon distribution, reproduction, and conservation status, turning the checklist into a CWR inventory. As reported by Magos Brehm *et al.* (2017b) the steps involved in the generation of a CWR inventory are: (i) compilation of a national flora (ii) matching the national flora against an existing digitized list of crop genera to obtain a list of taxa of the same genera as the list in the national flora, thereby producing the CWR checklist (iii) prioritization of the CWR checklist to generate a realistic and manageable number of priority CWR (iv) annotation of the priority list of CWR with additional information for active conservation action to produce a CWR inventory (Maxted *et al.*, 2007; Magos Brehm *et al.*, 2017b). Prioritization involves reducing the number of taxa in the CWR checklist into a number manageable for active conservation actions due to resource constraints and funding limitations. The prioritization criteria may include: crop socioeconomic value, CWR genetic closeness and ability to donate genes to the related crop, endemicity, occurrence, threat status and other related parameters (Magos Brehm *et al.*, 2017b; Thormann *et al.*, 2017). There is presently no complete CWR checklist or inventory for West Africa.

This paper aims at the generation of a regional CWR checklist for West Africa, prioritization of this CWR checklist and the compilation of a CWR inventory, using the method described by Maxted *et al.* (2007).

2.3 MATERIALS AND METHODS

2.3.1 Creation of a CWR checklist for West Africa

A monographic approach (for selected crop genera) was carried out in order to produce a digitized CWR checklist (Magos Brehm *et al.*, 2017b) for West Africa, including the following countries: Benin, Burkina Faso, Cape Verde, Cote d' Ivoire, Gambia, Ghana, Guinea, Guinea- Bissau, Liberia, Mali, Mauritania, Niger, Nigeria, Senegal, Sierra Leone and Togo. A digitized flora for families known to contain CWR taxa was compiled for 12 selected plant families. WCSP (2020) was used for the Araceae, Arecaceae, Convolvulaceae, Dioscoraceae, Euphorbiaceae, Musaceae, Poaceae and Zingiberaceae, while the regional printed flora (Huchinson and Dalziel, 1958) was used for the Malvaceae, Papilionaceae, Sterculiaceae and Caricaceae.

The following steps were involved in generating the CWR checklist:

(i) Produce a digitized list of regional flora

All taxa (i.e. species, subspecies, and varieties) belonging to the selected plant families were included in the floristic checklist. Information related to the different taxa of the regional flora were entered in the CWR checklist and inventory data template v.1 (Thormann *et al.*, 2017), including: family, genus, species and authorities, various sub-ranks, taxon, sub-taxon, taxon common name, synonyms, related crop(s) and common name of the related crop (Thormann *et al.*, 2017; Rahman *et al.*, 2019).

(ii) Produce a digitized list of crops

A digitized list of crop genera was produced from the following sources: (i) all crops cultivated in the world (FAO, 2021) (ii) major and minor food crops from the World Atlas of Biodiversity (Groombridge and Jenkins, 2002) (iii) Annex 1 of the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) for both forage and food crops (FAO, 2009b) The digitized list of crop genera was obtained from a published crop and crop genus list for CWR checklist and prioritization (Kell, 2016).

(iii) Match the crop genera against the floristic checklist to produce the CWR checklist

The digitized list of crops was matched against the floristic list to produce the CWR checklist. (Magos Brehm *et al.*, 2017b). Taxa cultivated but with no wild relatives in West Africa such as cocoyam (*Colocosia esculenta* (L) Schott), coconut (*Cocos nucifera* L), oil palm (*Elaeis guineesis* Jacq) or maize (*Zea mays* L) were removed. The draft CWR checklist was sent to experts and agricultural stakeholders for validation. The draft CWR checklist was approved by the experts and agricultural stakeholders for prioritization.

2.3.2 CWR Prioritization

Different criteria and methods have been used to prioritize CWR checklists in the past for several countries and regions of the world, depending on the country and who will fund the CWR conservation action (Magos Brehm *et al.*, 2017b). In this work, three criteria were applied in the prioritization of the CWR checklist for West Africa (Maxted, 2013), (i) crop value in West Africa from FAOSTAT (ii) CWR closeness to the crop from the Harlan and de Wet CWR diversity (https://www.cwrdiversity.org/checklist/) and (https://npgsweb.ars-grin.gov/gringlobal/taxon/taxonomysearchcwr.aspx), with CWR closeness restricted to gene pool or proven use in breeding within tertiary gene pool (GP3) (Maxted and Kell, 2009) (iii) global threat status according to IUCN (https://www.iucn.org/).

A parallel method was used through a point scoring process in which taxa were scored for all criteria, ranked according to their total score, and selected based on a 'cut off' score. For all criteria, taxa with a score of ≥3 were selected for prioritization. In assigning scores to criterion one (value), human food crops were scored (7 points), crops used as food additive (5), material (3), animal feed (1) and environmental use (1). Food crops (important for nutrition and food security), food additives and materials were selected for prioritization, excluding animal feed and environmental use crops. In assigning scores to the second criterion (genetic closeness), GP1 was scored (9 points), GP2 (7), GP3 (3), and CWR that lack this information [i.e. those belonging to Taxon Group 4 (TG4)] were scored (1 point). TG4 are CWR that belong to the same genus with their related crop. Applying the second criterion, CWR belonging to the primary gene pool (GP1B), secondary gene pool (GP2), and tertiary gene pool (GP3) with proven use in crop improvement were selected for prioritization (Ford-Lloyd *et* *al.*, 2008). Based on the third criterion (threat status), all evaluated CWR were selected for prioritization, excluding CWR that have not been evaluated (Maxted, 2013).

2.4 Results

The monographic CWR checklist for West Africa contains 1651 taxa from 379 genera. After the digitized list of crop genera was matched with the floristic list, a total of 392 CWR (and crops) resulted, belonging to 46 genera. Cultivated taxa without wild relatives in West Africa were removed, bringing the number to 379 taxa belonging to 33 genera. After applying the three criteria of the parallel method for prioritization (Ng'uni *et al.*, 2019), the CWR checklist was reduced to a total of 102 priority CWR from 18 genera with 24 subtaxon (subspecies/varieties). The priority CWR are related to 15 crops or/ crop groups important for the West African region. The families with the highest number of CWR species are Poaceae (39), Papilionaceae (26), Dioscoreaceae (15) and Convolvulaceae (13). The genus with the highest number of CWR are Vigna (23), Dioscorea (15), Ipomoea (13), Oryza (6) and Cola (5) (Table 2.1)

Table 2.1 Number of priority CWR for West Africa

Family	Genus	Related crop	No of CWR taxa
Areceae	*Phoenix*	Date palm	1
Convolvulaceae	*Ipomoea*	Sweet potato	13
Dioscoreaceae	*Dioscorea*	White yam	15
Euphorbiaceae	*Manihot*	Cassava	5
Malvaceae	*Gossypium*	Cotton	3
Papilionaceae	*Phaseolus*	Common bean, kidney bean	3
	Vigna	Cowpea	23
Poaceae	*Digitaria*	Fonio	4
	Eleusine	Finger millet	3
	Eragrostis	Teff	4
	Hordeum	Barley	2
	Oryza	Rice	6
	Saccharum	Sugarcane	2
	Sorghum	Sorghum	4
	Triticum	Wheat	2

Family	Genus	Related crop	No of CWR taxa
	Panicum	Proso millet	2
Sterculiaceae	*Cola*	Kola nut	5
		Total CWR	102

2.4.1 Socioeconomic Value of Related Crop

Yam (*Dioscorea cayenensis* subsp. *rotundata* (Poir) J. Miege) is the most economically valuable crop in West Africa, with the highest gross production value. It is followed by cassava (*Manihot esculenta* Crantz), rice (*Oryza sativa* L.), finger millet (*Eleusine coracana* (L) Gaertn), sorghum (*Sorghum bicolor* (L) Moech) and cowpea (*Vigna unguiculata* (Linn) Walp.) (Figure 2.1). Yam (*Dioscorea cayenensis* subsp. *rotundata* (Poir) J. Miege) also has the second largest number of CWR (15) after cowpea (23). Cassava (*Manihot esculenta* Crantz) and rice (*Oryza sativa* L.) which are the second and third in gross production value, have 5 and 6 CWR, respectively, in the inventory (Table 2.1).

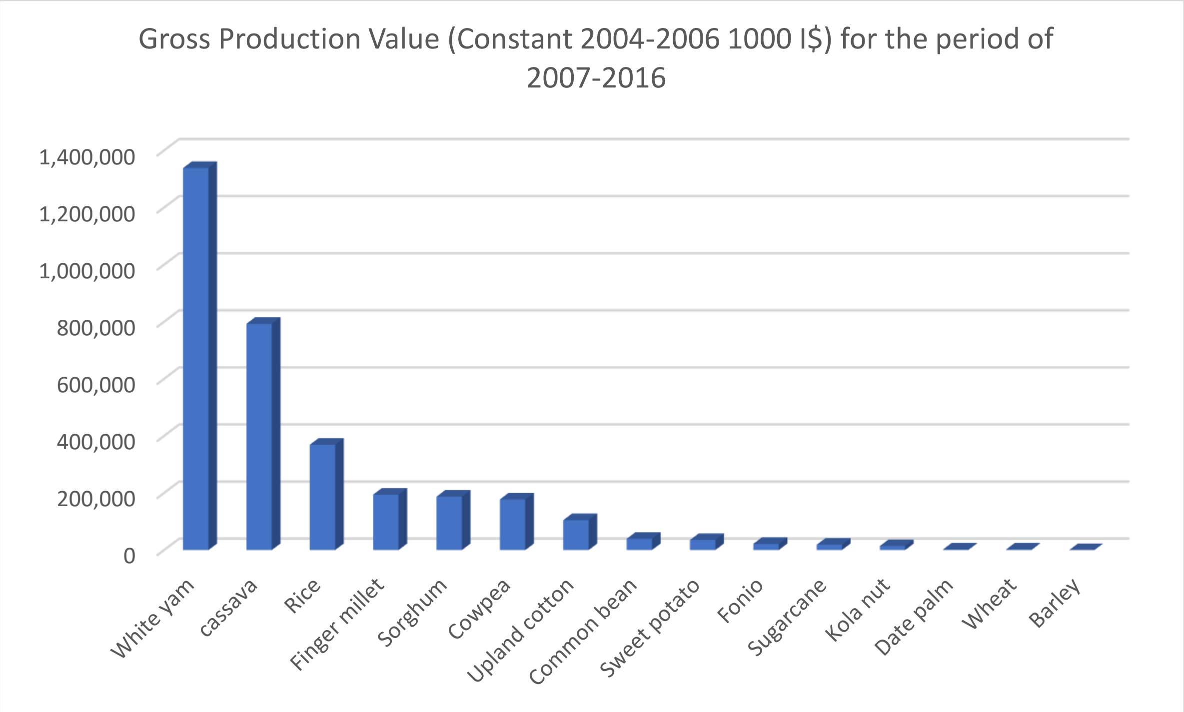

Fig 2.1 Gross Production Value for the period of 2007-2016 of socioeconomically valuable crops in West Africa. Data source: (FAO, 2021).

2.4.2 CWR Closeness to Related Crop

Forty-five 45 (44 %) of the taxa were selected for prioritization using the criterion of taxa belonging to gene pools GP1B, GP2 or proven use of GP3 in crop improvement. Among the CWR selected, 21 (20.58 %) belong to GP1B, 28 (27.4%) are GP2 while 53 (51.9%) belong to (GP3 or / Taxon Group 4) (Table 2S

1). Among the 53 CWR belonging to GP3/Taxon Group 4, 3 (2.9%) have potential and confirmed use in crop improvement. 22 (21.7%) of the CWR have confirmed use in crop improvement for crops such as wheat, rice, yam, sorghum, cassava, cowpea, millet, and cotton, contributing to yield improvement, drought tolerance and resistance to several diseases in different crops as well as fibre quality in cotton (Table 2.2). Out of the 14 CWR taxa in the genus *Dioscorea,* 5 have confirmed use in crop improvement against various diseases such as anthracnose, yam mosaic virus (YMV) and yam nematode. Four CWR out of six in the genus *Manihot* have confirmed utilization for crop improvement against cassava brown streak disease (CBSD).

2.4.3 Threat Status of CWR

The threat status of 71 (69.6%) of the priority CWR has been determined under the IUCN threat assessment criteria (IUCN, 2012b). All the priority CWR were globally assessed. *Vigna desmodioides* Wilczek is the only Endangered (EN) priority CWR. Two priority CWR are Near Threatened (NT): *Dioscorea sensibarensis* Pax and *Gossypium anomalum* Wawra. Two CWR are Data Deficient (DD): *Gossypium herbaceum* var *acertifolium* (Guill & Perr.) A Chev and *Oryza brachyantha* A Chev & Roehr. Sixty- six (64.7%) of the priority CWR are Least concern (LC) while 31 (30.4%) were Not Evaluated (NE) (Fig 2.2). Rice (*Oryza sativa* L.) was the only socioeconomically valuable crop that had all its CWR assessed for threat status (Huchinson and Dalziel, 1958).

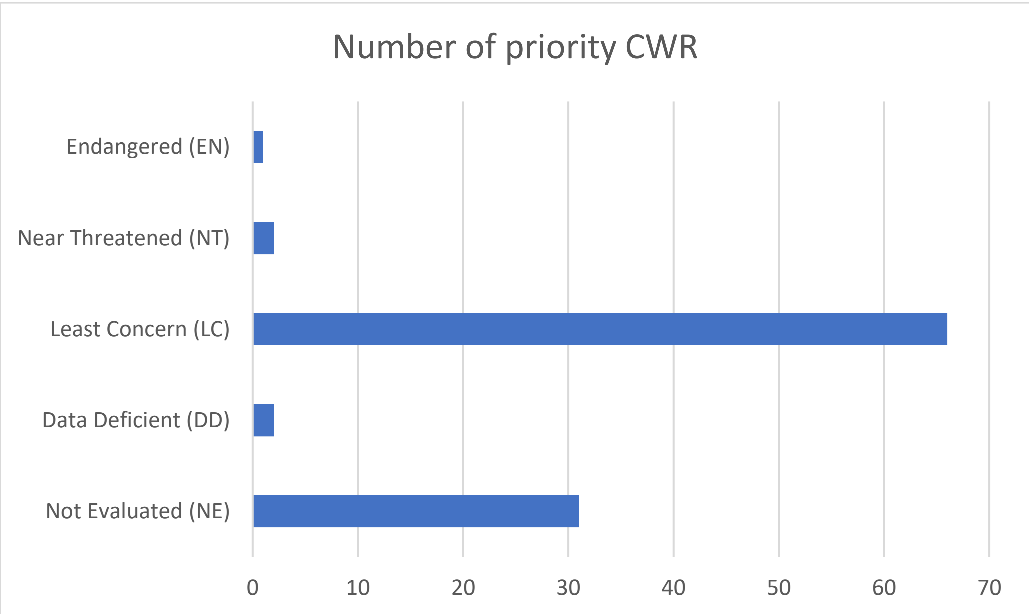

Fig 2. 2 Number of priority taxa in the IUCN categories. Data source: (IUCN, 2020).

2.4.4 CWR Distribution

84 (69%) of the priority taxa were regionally endemic to West Africa, and 10 (8%) were nationally endemic. The nationally endemic priority taxa included: *Oryza eichingeri* Peter and *Cola attiensis*

Aubrev. & Pellegr (Cote D' Ivoire), *Cola angustifolia* K. Schum (Sierra Leone), *Ipomoea intrapilosa* Rose, *Ipomoea prismatosyphon* Welw, *Vigna ambacensis* Welw ex Bak, *Vigna macrorrhyncha* (Harms) Milne – Redhead, *Cola altissima* Engl and *Cola argentea* Mast (Nigeria) (Huchinson and Dalziel, 1958) (Table 2S2). Six (5%) priority taxa were found in all 15 countries in West Africa and include: *Echinochloa colonum* (L) Link, *Echinochloa pyramidis* (Lam) Hitchc & Chase, *Eragrostis japonica* (Thunb) Trin, *Eragrostis pilosa* (L) P. Beauv, *Oryza barthi* A Chev and *Eleusine indica* (L) Gaertn (Huchinson and Dalziel, 1958; WCSP, 2020) (Table 2S2).

Table 2.2 Confirmed and potential use of priority CWR for Nigeria and West Africa in crop improvement

Crop	**CWR**	**Confirmed and Potential use**
White Guinea yam	*Dioscorea abyssinica* Hochst ex Kunth	Yam mosaic virus (YMV) and anthracnose resistance (Lopez- Montes *et al.*, 2012)
	Dioscorea praehensilis Benth	Yam mosaic virus (YMV) and anthracnose resistance (Lopez- Montes *et al.*, 2012)
	Dioscorea alata L.	Anthracnose resistance, improved cooking quality and reduced tuber oxidation (Lopez- Montes *et al.*, 2012)
	Dioscorea bulbifera L.	Yield improvement (Saini *et al.*, 2016)
	Dioscorea cayenensis Lam	Anthracnose and yam nematode resistance, drought tolerance (Lopez-Montes *et al.*, 2012)
Cassava	*Manihot esculenta* subsp. *peruviana* Crantz	Cassava brown streak disease (CBSD) resistance (Kawuki *et al.*, 2016)
	Manihot carthagenensis subsp. glaziovii (Mull. Arg.) Allem	
	Manihot dichotoma Ule	

Crop	CWR	Confirmed and Potential use
Cotton	*Gossypium barbadense* Linn	High fibre quality (Zamir, 2001; Shi *et al.*, 2008)
Barnyard millet, Japanese millet	*Echinochloa crus-galli* P. Beauv *Echinochloa frumentacea* Link	High yield (Sood *et al.*, 2015)
Finger millet	*Eleusine africana* Kenn. -O' Byrne	High yield (Dida and Devos, 2006)
Barley	*Hordeum bulbosum* L.	Barley mild mosaic virus resistance (Walther *et al.*, 2000; Ruge *et al.*, 2003; Wendler *et al.*, 2015), barley yellow dwarf virus resistance (Scholz *et al.*, 2009; Wendler *et al.*, 2015), barley yellow mosaic virus resistance (Ruge-Wehling *et al.*, 2006), leaf rust resistance (Shtaya *et al.*, 2007; Johnston *et al.*, 2013; Park *et al.*, 2015), leaf scald resistance (Pickering *et al.*, 2006; Wendler *et al.*, 2015), powdery mildew resistance (Pickering and Johnston, 2005; Johnston *et al.*, 2009), stem rust resistance (Fetch Jr *et al.*, 2009), potential use for soil salinity tolerance (Tavili and Biniaz, 2009), potential use for high yield (Kakeda *et al.*, 2008).
Rice	*Oryza eichingeri* Peter	Potential use for brown planthopper resistance, green leafhopper resistance and white backed planthopper resistance (Jena, 2010), submergence tolerance (Atwell *et al.*, 2014)
	Oryza barthii A Chev.	Potential use for drought tolerance (Atwell *et al.*, 2014)
	Oryza glaberrima Steud.	Drought tolerance (IRRI, 2007), iron tolerance (Brar and Khush, 2002), rapid leaf canopy establishment (Jones *et al.*, 1997), potential for acid soil tolerance (Brar and Khush, 2002), potential for heat tolerance (Atwell *et al.*, 2014)
	Oryza longistaminata A. Chev & Roehr	Drought tolerance (Hajjar and Hodgkin, 2007), yield improvement (Brar, 2005), bacterial blight resistance (Brar, 2005; Jena, 2010)

Crop	CWR	Confirmed and Potential use
Sorghum	*Sorghum purpureosericeum* (Hochst. ex A. Rich)	Sorghum shoot fly resistance (Nwanze *et al.*, 1990)
	Sorghum bicolor subsp. *verticilliflorum* (L.) Moench	Leaf rust resistance (Park *et al.*, 2015), spot blotch resistance (Yun *et al.*, 2006), stem rust resistance (Fetch Jr *et al.*, 2009), drought tolerance (Nevo and Chen, 2010), seed weight (Pillen *et al.*, 2004)
Common bean, kidney bean	*Phaseolus vulgaris* var *aborigineus* L.	Drought tolerance (Blair *et al.*, 2016), plant height (Blair *et al.*, 2006), seed size (Blair *et al.*, 2006), yield improvement (Wright and Kelly, 2011), bruchid resistance (Osborn *et al.*, 2003), common bacterial blight resistance (Beaver *et al.*, 2012), web blight resistance (Beaver *et al.*, 2012), white mold resistance (Mkwaila *et al.*, 2011). Potential for bean rust resistance (Acevedo *et al.*, 2006), potential for fusarium root rot resistance (De Ron *et al.*, 2015)
Cowpea	*Vigna unguiculata* subsp. *dekindtiana* (L.) Walp.	Pod bug resistance (Timko and Singh, 2008)
	Vigna unguiculata subsp. *unguiculata* var. *spontanea* (L.) Walp.	Yield improvement (Andargie *et al.*, 2014)
	Vigna unguiculata subsp. *stenophylla* (L.) Walp.	Potential for aphid resistance (Badiane *et al.*, 2014)
Wheat	*Triticum turgidum* L	Stripe rust resistance (Chaudhary *et al.*, 2014), powdery mildew resistance (Chaudhary *et al.*, 2014)

2.5 DISCUSSION

Adejuwon (2000) reported that 20 species of plants in Nigeria are extinct, 431 are endangered species while 20 are vulnerable. Urbanization, soil degradation, natural calamities, deforestation, forest fires, overgrazing and other anthropogenic activities, particularly climate change are reducing the avaliability of CWR for sustainable agricultural productivity (Maxted *et al.*, 1997a; Moore *et al.*, 2008;

Mounce *et al.*, 2017). For an effective and sustainable regional conservation strategy and its subsequent implementation, a priority CWR inventory is essential. A CWR inventory serves as a guide for a sustainable conservation action plan. The outcome of this research will form the blueprint for a systematic conservation and use strategy for West Africa. It will provide a starting point for a coordinated policy in the conservation and sustainable utilization of CWR diversity in the West African region. In this study, 379 taxa were identified as priority plant taxa, of which 102 were subsequently prioritized for urgent active conservation action. The remaining 257 plant species and their CWR could be considered for active conservation in the future as and when resources becomes avalaible.

CWR of socioeconomic valuable crops in West Africa have been reportedly used in crop improvement. For instance, Sood *et al.* (2015) reported the use of *E. crusgalli* P. Beauv and *E. frumentacea* Link to increase yield quality in Barnyard millet. *D. abysinica* Hochst ex Kunth and *D. praehensilis* have been reported to show resistance to yam mosaic virus and anthracnose (Lopez- Montes *et al.*, 2012), while *D. bulbifera* showed resistance to yam nematode and tolerance to drought (Lopez- Montes *et al.*, 2012). Similarly, Kawuki *et al.* (2016) reported the use of *M. esculenta* subsp. *peruviana* Crantz, *M. carthagenensis* subsp. *glaziovii* (Mull. Arg.) Allem, *M. dichotoma* Ule and M. esculenta subsp. *flabellifolia* Crantz in breeding against cassava brown streak disease in cassava (Table 2.2). Traits for drought tolerance (Hajjar and Hodgkin, 2007), yield improvement (Brar, 2005) and bacterial blight resistance (Brar, 2005; Jena, 2010) have been transferred from *O. longistaminata* A. Chev. & Roehr to rice, while *O. glaberrima* Steud has been reported to show drought tolerance (IRRI, 2007), iron tolerance (Brar and Khush, 2002), rapid leaf canopy establishment (Jones *et al.*, 1997) and potential for tolerance to acid soil (Brar and Khush, 2002) and heat (Atwell *et al.*, 2014). Also, *S. bicolor* subsp. *verticillifolia* (L) Moench has reportedly shown resistance to leaf rust (Park *et al.*, 2015), spot blotch (Yun *et al.*, 2006), stem rust (Fetch Jr *et al.*, 2009) and tolerance to drought (Nevo and Chen, 2010). Resistance to white mold (Mkwaila *et al.*, 2011), bruchid (Osborn *et al.*, 2003), common bacterial blight and web blight (Beaver *et al.*, 2012) and tolerance to drought have been documented in *Phaseolus vulgaris* var, *aborigineus* L. Chaudhary *et al.* (2014) stripe rust and powdery mildew resistance in *T. turgidum* L. (Table 2.2).

Maxted *et al.* (2015) and Kell *et al.* (2017) have opined that regional conservation is supplemental to national efforts as some CWR may be lacking in some countries in a region. West Africa, being a region dominated by agricultural nations, will find the implementation of the conservation plan from this inventory useful, as it will enhance the region's global relevance in agricultural productivity. As reported by Maxted *et al.* (2008c) and Engels and Thormann (2020) collaboration by neighbouring nations could enhance the extensive and effective conservation of CWR genetic diversity. It is therefore the collective responsibilities of the neighbouring nations where these CWR diversity are found to regionally conserve them (Maxted *et al.*, 2008c; Maxted *et al.*, 2015; Kell *et al.*, 2017; Allen *et al.*, 2019).

2.6 CONCLUSION

This study shows that West Africa harbour CWR diversity that can contribute significantly to sustainable agricultural development in the region. Kell *et al.* (2015) noted that countries should widen their utilization of CWR across national boundaries and all ntions are interindependent in the quest for food security. Similar to a existing CWR inventory for the North African region (Lala *et al.*, 2018), the CWR checklist, prioritization and prioritized inventory presented in the study will help in the development of a CWR conservation plan for West Africa. The conservation and utilization of CWR in this inventory for crop improvement has the potential to significantly reduce the overdependence on synthetic agrochemicals and fertilizers in the region, which negatively impacts its biodiversity and agricultural productivity. There is an urgent need to take a systematic and pragmatic approach in the conservation and sustainable utilization of CWR diversity in West Africa to ensure food security.

CHAPTER 3

IN SITU AND *EX SITU* CONSERVATION GAP ANALYSES OF WEST AFRICAN PRIORITY CROP WILD RELATIVES

The work presented in this chapter has been published in Genetic Resources and Crop Evolution

Nduche, M. U., Magos Brehm, J., Parra- Quijano, M. and Maxted, N. (2023). *In situ* and *ex situ* conservation of West African crop wild relatives. Genetic Resources and Crop Evolution 70: 333 – 351. https://doi.org/10.1007/s10722-022-01507-2

3.1 ABSTRACT

Crop wild relatives are genetically related wild taxa of crops with unique resources for crop improvement through the transfer of novel and profitable genes. The *in situ* and *ex situ* conservation gap analyses for priority crop wild relatives from West Africa were evaluated using species distribution modelling, ecogeographic diversity, and complementary analyses. A total of 20, 125 unique occurrence records were used for the conservation gap analysis, however, 26 taxa had no occurrence data. 64 taxa (62.7%) occurred in protected areas, 56 taxa (55%) were conserved *ex situ*, while 76.7% (43) of the accessions are underrepresented with less than 50 accessions conserved *ex situ*. Areas of highest potential diversity were found in the Woroba and Montangnes districts in Cote d'Ivoire, Nzerekore, Faranah, Kindia, and Boke regions of Guinea, South-South, and North-East zones of Nigeria, and Kono and Koinadugu districts in Sierra Leone. Hotspots were found in Atlantique, Littoral, Mono, Kouffo, Atakora, Donga, and Colline provinces of Benin, Accra, and Volta regions of Ghana, North–Central Nigeria, and Lacs district of Cote d'Ivoire and Nzerekore region of Guinea. 29 reserve sites for active *in situ* conservation were identified, 11 occur in protected areas, while 18 are located outside protected areas. The establishment of the reserve sites will complement existing PAs and ensure long-term active *in situ* and *ex situ* conservation and sustainable utilization of priority crop wild relative to underpin food security and mitigate climate change in the region.

Keywords: CAPFITOGEN, Crop wild relatives, diversity analysis, *ex situ*, genetic conservation, in *situ*, and species distribution modelling.

3.2 INTRODUCTION

The flora of West Africa is diverse, heterogeneous, and abundant with numerous plant species. The region harbours over 9000 vascular plants with an estimated 1,800 species native to West Africa (Carr *et al.*, 2015). The climate of West Africa is characterised by abundant year-round rainfall in the Gulf of Guinea to a mean annual rainfall of 165 mm in the Agadez of Niger (USGS, 2017). Five bioclimate regions have been recognized in West Africa; Saharan, Sahelian, Sudanian, Guinean, and Guinea – Congolian regions (USGS, 2017). As such, West African plant species are adapted and resilient to the region's erratic, and diverse ecogeographic conditions and may possess useful genes/traits for crop improvement. West Africa is recognized as a region that played a significant role in crop diversity, origin and domestication, and still retains significant crop landraces and CWR diversity (Castañeda-Álvarez *et al.*, 2016; Vincent *et al.*, 2019; Maxted and Vincent, 2021). For instance, archaeological records shows that cowpea (*Vigna unguiculata* (L.) Walp.), originated from Ghana (D'Andrea *et al.*, 2007), kola nut (*Kola nitida* (Vent.) Schott. & Endl.) originated from West to Central Africa, from Sierra Leone to Congo (Lovejoy, 1980), African oil palm (*Elaeis guineesis* Jacq.) originated from West and Central Africa, from Nigeria and Cameroon to Congo (Carney, 2001; Hall, 2008), while *Coffea canephora* Pierre ex A. Froehner (bitter and caffeinated coffee) originated from Central Africa to West Africa (between Congo, Central African Republic, Cameroon, Cote d'Ivoire and Guinea) (Leroy *et al.*, 2014) Similarly, fonio [*Digitaria exilis* (Kippist) Stapf] was domesticated in Senegal (Harlan, 1992) and Pearl millet was domesticated between Mali and Mauritania (Burgarella *et al.*, 2018). The zone between Ghana and Nigeria, down to Cameroon has been identified as the source of yam domestication (Scarcelli *et al.*, 2019), fleshy watermelon [*Citrullus lanatus* (Thunb.) Matsum. & Nakai] was domesticated in West Africa from *C. mucosospermus* (Fursa) Fursa (Guo *et al.*, 2013; Chomicki *et al.*, 2019; Guo *et al.*, 2019). Other crops domesticated in West Africa include Garden egg (*Solanum macrocarpon* L.), Locust bean [*Parkia biglobosa* (Jacq.) G. Don], Pigeon pea [*Cajanus cajan* (L.) Millsp], Cotton (*Gossypium herbaceum* L.), Okra [*Abelmoschus esculenta* (L.) Moench, Piper seed (*Piper guineensis* Schumach. & Thonn.), Tamarind (*Sesamum indicum* L.), and Gourd (*Telfairia occidentalis* Hook. f.) (MacNeish, 1992; Vaughan and Geissler, 1999; Carney, 2001). Seed cotton, domesticated in West Africa is ranked among the first ten crops in feeding in the world, while watermelon is among the five most economically valuable fruits in the world (FAOSTAT, 2020). The extent of crop diversity in West Africa through these crops, has helped to expand the agricultural repertoire beyond the reliance on few global food crops (Champion and Fuller, 2018; Kay *et al.*, 2019). The importance of West Africa in terms of crop and intra-crop diversity, and origin and domestication of cultivated crops has recently been recognized by the adding of an additional Vavilov Centre in the west African region (Maxted and Vincent, 2021).

Global food production in the next few decades will be determined by several factors including climate change. Climate change will negatively impact agricultural productivity in a global yield decline of an estimated 1.5% per decade (David and Sharon, 2012). This trend can at least be partially mitigated by the genetic and agronomic improvement of cultivated crops using trait diversity from crop wild relatives (CWR) (Maxted *et al.*, 2008b; David and Sharon, 2012). CWR are wild plant species relatively closely related to crops, including crop's wild ancestors, that retain indirect use value as gene donors for crop improvement and a high level of genetic diversity having not passed through the genetic bottleneck of domestication. Maxted *et al.* (2006) defined CWR broadly as all taxa within the same genus as a crop and more precise as wild plant taxon that have indirect use derived from its relatively close genetic relationship to a crop; this relationship is defined in terms of the CWR belonging to gene pools 1 or 2, or taxon groups 1 to 4 of the related crop. CWR contain resilient genes for crop improvement with several domesticated crops in West Africa improved using adaptive genes from

CWR (Nduche *et al.*, 2021). Such crops include cassava (David and Sharon, 2012; Kawuki *et al.*, 2016), maize (David and Sharon, 2012), yam (Lopez- Montes *et al.*, 2012; Saini *et al.*, 2016), cowpea (Andargie *et al.*, 2014; Badiane *et al.*, 2014), millet (Sood *et al.*, 2015), sorghum (Park *et al.*, 2015), rice (Jena, 2010; Atwell *et al.*, 2014), barley (Wendler *et al.*, 2015), and for an overview (Nduche *et al.*, 2021).

Despite the important role of CWR in food security in the West African region and the world, their conservation has received little attention. The neglect of CWR is because of lack of appreciation of its potential value in breeding and has resulted in underutilization of its profitable genetic diversity in crop improvement. The adaptive diversity of CWR is a safety net for urgent global food security needs. Globally, *in situ* conservation of CWR in protected area (PAs) is inadequate, with insufficient number of genetic reserves established (Iriondo *et al.*, 2012). In West Africa, 1938 nationally protected sites exist covering about 9.6 % of the region. Another 53 internationally designated protected areas are also found in the region (Mallon *et al.*, 2015). The number of CWR accessions conserved *ex situ* in genebanks is relatively low compared to accessions of cultivated crops. Globally, there are an estimated 7 million plant accessions conserved in 1750 genebanks (FAO, 2010; Fu, 2017), however, about 29 % of CWR lack genebank accessions, while over 24 % have less than ten accessions represented in genebanks (Castañeda-Álvarez *et al.*, 2016). Despite this shortfall in *ex situ* conservation of CWR, a comprehensive collection of CWR is still lacking. The combined use of *in situ* and *ex situ* conservation of plant genetic diversity will lessen the erosion of valuable genetic diversity (Maxted *et al.*, 1997a; Zegeye, 2017).

Despite the wide agreement that *in situ* and *ex situ* techniques should be applied in a complementary manner (CBD, 1992), almost 100% of CWR diversity when conserved are conserved using *ex situ* seed storage alone (Maxted *et al.*, 2016). *In situ* conservation is only recently being implemented and involves the designation of and management of populations to preserve a particular plant species in its natural abode where its intrinsic features are found (Maxted *et al.*, 1997c). To help ensure more *ex situ* and *in situ* conservation coverage, more recently, gap analysis has been applied for the planning of CWR conservation (Maxted, 2013). It involves identifying CWR diversity that is not well represented in conservation action and prioritizing these 'gaps' for more active conservation (Maxted *et al.*, 2008a; Magos Brehm *et al.*, 2017a; Ng'uni *et al.*, 2019; Mponya *et al.*, 2020; Magos Brehm *et al.*, 2022).

The aim of this study was to undertake *in situ* and *ex situ* conservation gap analyses of West African priority CWR, through (a) evaluating the spatial distribution of West African priority CWR (b) modelling the predicted distribution of the priority CWR (c) identifying the reserve sites in PAs for active *in situ* conservation of priority CWR and locations with inadequate occurrence records (d) identifying taxa that are not present in PAs and those absent or under-represented in genebanks, for further *ex situ* collection and effective preservation in genebanks within the region.

3.3 MATERIALS AND METHODS

3.3.1 Collation and Verification of Occurrence Data

The distributional data for the 102 West African priority CWR defined by Nduche *et al.* (2021) was collated using a standard occurrence data template (Magos Brehm *et al.*, 2017b). The occurrence data of the West African priority CWR were collated from Global Biodiversity Information Facility (GBIF, 2020), Genesys Global Portal on Plant Genetic Resources (Genesys, 2020), Royal Botanical Gardens, Kew (https://www.kew.org/kew-gardens), and RainBio (Dauby *et al.*, 2016). A total of 54,924 distributional records were collated for the 102 West African priority CWR. Records that lacked coordinates but with collection site information were georeferenced, using Google maps (https://www.maps.google.com). A quality check was done on the distributional data to ensure all records were expressed in decimal degrees. Locational records without decimal degree coordinates were converted to a decimal degree using Canadensys (https://www.data.canadensys.net/tools/coordinates). Duplicate records were removed before the analysis, and records that lay abnormally in neighbouring countries were reviewed. Duplicate records are distributional records that are associated with the same record but from different sources or were documented twice from the same source (Magos Brehm *et al.*, 2017a). The West African countries included in this study are Benin, Burkina Faso, Cote D' Ivoire, Gambia, Ghana, Guinea, Guinea- Bissau, Liberia, Mali, Mauritania, Niger, Nigeria, Senegal, Sierra Leone and Togo. The 20,125 records without duplicate records were entered in the occurrence data template required by the CAPFITOGEN tool which makes use of the FAO- Biodiversity's multi-crop descriptor (FAO-BIOVERSITY, 2015). The 'TesTable tool' of CAPFITOGEN3 was used to verify the occurrence data table to ensure it meets the requirements for other CAPFITOGEN3 tools analyses. The GEOQUAL tool of CAPFITOGEN3 was used to assess the quality of coordinates and collection sites of the records (Parra - Quijano *et al.*, 2021).

3.3.2 Ecogeographical Land Characterization Map

Ecogeographic land characterisation (ELC) (Parra - Quijano *et al.*, 2021) was used to evaluate the delineation and depiction of ecogeographic variables and determine appropriate sites for *in situ* and *ex situ* conservation of priority CWR (Parra-Quijano *et al.*, 2011; Magos Brehm *et al.*, 2022). Eighteen environmental variables (6 bioclimatic, 6 edaphic, and 6 geophysical) were selected in the SelecVar tool of CAPFITOGEN3, to generate the generalist ELC map. A total of 24 ELC zones were produced, representing the region's predicted ecogeographic scenarios (Fig. 3.5) (Parra-Quijano *et al.*, 2012a;

Mponya *et al.*, 2020). To accommodate those taxa with distributional records of <10, a generalist ELC map was generated using the ELC maps tool of CAPFITOGEN3. This is because these taxa cannot generate species-specific ELC map. Using the kmeanbic method, at a resolution of the ecogeographic layer of 10 x 10 km (approximately 5 arc – minutes), the ELC map was created. The kmeanbic method was used because it identifies an optimal number of groups with discriminant analysis of principal components.

3.3.3 Species Distribution Modelling

Based on environmental layers of various components of ecogeographic variables, predicted taxa distribution was identified by the distribution models produced by the individual taxa with more than 10 occurrence records in the Maximum Entropy Algorithm (MaxEnt) (Phillips *et al.*, 2006)(Table 3S6) and by circular buffer (CA_{50}) for taxa with less than 10 occurrence records used in the species distribution modelling (SDM), MaxEnt is a common SDM algorithm used to predict taxa distribution (Fourcade *et al.*, 2014). The species distribution data of the taxa for model calibration was classified into a training set (75% of total occurrence data) and a test set (25% of total occurrence records) for design evaluation. Raster files of bioclimatic variables were obtained from WorldClim (https://www.worldclim.org/bioclim), edaphic variables, from ISRIC – World Soil Information (https://files.isric.org/soilgrids/), while geophysical data were downloaded as Digital Elevation Map (DEM) files from the National Aeronautics and Space Administration (NASA) (https://www.nasa.gov.) All ecogeographic raster files were clipped to the same extent, resampled to the same cell size (0.41666666667 m), and reprojected to the same grid (WGS - 84), in ASCII raster grid format, using ArcMap 10.4.1(ESRI, 2015). With Random Forest, integrated into the SelectVar of the CAPFITOGEN tools, variables for each ecogeographic component (bioclimatic, edaphic and geophysical) at a resolution of 10 X 10 Km (approximately 5 arc minutes at the Equator) were selected for each priority taxon (Parra-Quijano *et al.*, 2016). Bivariate correlation analysis was also evaluated in SelecVar, to reduce dimensionality and only variables with weak correlation (p-value ≤ 0.33) or not correlated (p-value = 0) were used to create the distribution model for each taxon (Tables 3S7 and 3S8). Maximum training sensitivity plus specificity threshold was applied, as recommended by Liu *et al.* (2005). The robustness of the models was evaluated using three criteria: (a) average area under the test receiver operating characteristics curve [(ATAUC) > 0.7] (b) standard deviation of ATAUC (STAUC) < 0.15 (c) the proportion of potential distribution area with a STAUC > 0.15, being < 10% were stable and used for evaluating taxa predicted distribution (Ramírez-Villegas *et al.*, 2010; Mponya *et al.*, 2020). All three criteria had to be met for a model to be valid. However, for those taxa that failed the above MaxEnt model validation criteria, and for taxa with occurrence records < 10, predicted distribution was identified by a circular buffer technique, using a radius of 50 km (CA50) around each observational point as recommended by Hijmans and Spooner (2001). In this case, intersecting sites are not counted more than once.

3.3.4 *In Situ* Conservation Gap Analysis

Gap analysis is a method of evaluation of the extent of conservation which helps to hierarchize CWR for preservation by locating gaps in the conservation (Rodrigues *et al.*, 2004; Langhammer *et al.*, 2007; Magos Brehm *et al.*, 2017a). *In situ* conservation gap analysis involves a comparative study of intrinsic diversity and the element of diversity that is under active conservation action (Maxted *et al.*, 2008b; Magos Brehm *et al.*, 2017a) The method was described by Maxted *et al.* (2008b), Scheldeman and van Zonneveld (2010) and Parra-Quijano *et al.* (2012b) where *in situ* and *ex situ* conservation gap analyses were determined at taxon and ecogeographic levels. At the taxon level, the West African PA map was overlapped with the passport data in QGIS. Subsequently, using 'the join attribute by location' in the 'data management tool' of QGIS, the West African PA maps were intersected to identify records within and outside PA. The *in situ* conservation gaps were obtained by comparing the number of populations of taxa present in PAs against those not represented in PAs (Mponya *et al.*, 2020). To estimate the extent of representativeness of *in situ* conservation of priority CWR at the ecogeographic level, the ELC zones from the ELC map tool analysis and the occurrence data were inputted in the 'Representa tool' of CAPFITOGEN3 (Parra - Quijano *et al.*, 2021). The West African PA maps were overlapped with the ELC maps produced in the 'Representa tool' to determine the representativeness of the ELC zones in PAs.

Complementarity analysis was done to identify potential sites for *in situ* conservation of priority CWR. Maxted *et al.* (1997b) described these sites as genetic reserves for the long–term active conservation of plant genetic resources. They are defined as designated locations either within PAs or outside PAs as informal sites for CWR conservation (Magos Brehm *et al.*, 2017a). Such locations are aimed at conserving a large number of CWR taxa in the smallest available area (Kati *et al.*, 2004). Using the 'Reserve selection' tool in DIVA-GIS 7.5, at a resolution of 10 x 10 km (approximately 5 arc minutes), potential genetic reserve sites were identified according to their priority for the conservation of priority CWR. The PA map for West Africa, obtained from UNEP-WCMC (2019) was overlapped with the complementarity genetic reserve site and taxon richness maps to determine the level of current passive *in situ* conservation of the priority CWR and identify areas that require further active *in situ* conservation actions. Passive *in situ* conservation means that CWR in PAs are not actively monitored and managed to preserve their genetic diversity and protect them from pests, diseases, fragmentation, habitat degradation, and natural disasters (Vincent *et al.*, 2019). The maps produced were visualized in DIVA-GIS 7.5 (Hijmans *et al.*, 2012) and QGIS 3.16.8 (QGIS-Development Team, 2021).

3.3.5 *Ex situ* Conservation Gap Analysis

Ex situ conservation gap analyses were determined at taxon and ecogeographic levels. At the taxon level, a map of observed *ex situ* collection was subtracted from the predicted distribution map to obtain the gap in current *ex situ* conservation and locate the priority site for further *ex situ* collection. To determine the current germplasm representativeness of the ecogeographic diversity, the resulting ELC map, and passport data were inputted in the 'Representa' tool of CAPFITOGEN to assess the degree of representativeness of the ELC categories in the *ex situ* collection (Parra-Quijano *et al.*, 2016). The maps were processed in DIVA-GIS 7.5 (Hijmans *et al.*, 2012), ArcMap 10.7 (ESRI, 2011) and QGIS 3.16.8 (QGIS-Development Team, 2021) at a resolution of 10 x 10 km (approximately 5 arc minutes). At the ecogeographic level, the categories of representativeness of the diversity were analyzed using the 'Representa tool' of CAPFITOGEN3 (Parra - Quijano *et al.*, 2021). Based on the frequencies of the ELC map, the ELC map was categorized into quartiles, using the ELC zones in the ELC map. The four frequency classes were low, mid-low, mid-high, and high. However, zones, where occurrence records were not found, were categorized as 'null'. *Ex situ* conservation gaps were determined by estimating the diversity present in *ex situ* conservation against that conserved *in situ* (Mponya *et al.*, 2020; Parra - Quijano *et al.*, 2021).

3.4 RESULTS

3.4.1 *In situ* gap analysis

A total of 20,125 unique occurrence points were used for the *in situ* conservation gap analysis, however 26 CWR had no occurrence data. The highest occurrence points were recorded in Benin and Nigeria with 31.9% (6428) and 11.7% (2,358) present points, respectively (Fig.s 3.1 and 3S1). Hotspots were found in Atlantique, Littoral, Mono, Kouffo, Atakora, Donga, and Colline provinces of Benin. These areas correspond to the location of protected areas with the highest number of taxa such as Pendjari (28), Quari Maro (18), La Lama Nord (16), Monts Kouffe, and Boucle de la Pendjari (18) (Table 3S1) There were also hotspots in Accra and Volta regions of Ghana, corresponding to the location of the Volta River reserve site. Locations of high diversity were also spotted around Nasarawa, Plateau States of North-Central Nigeria, where Nasarawa Forest Reserve is located, and the South-Western zone of Nigeria. High species richness is also observed in the Lacs district of Cote d'Ivoire where the Mando forest reserve is situated, the Montagnes district of Cote d' Ivoire where Mont Nimba is located, and Nzerekore region of Guinea where Mont Nimba, Pic de Fon and Pic de Tibe Classified Forests are located (Fig. 3.2).

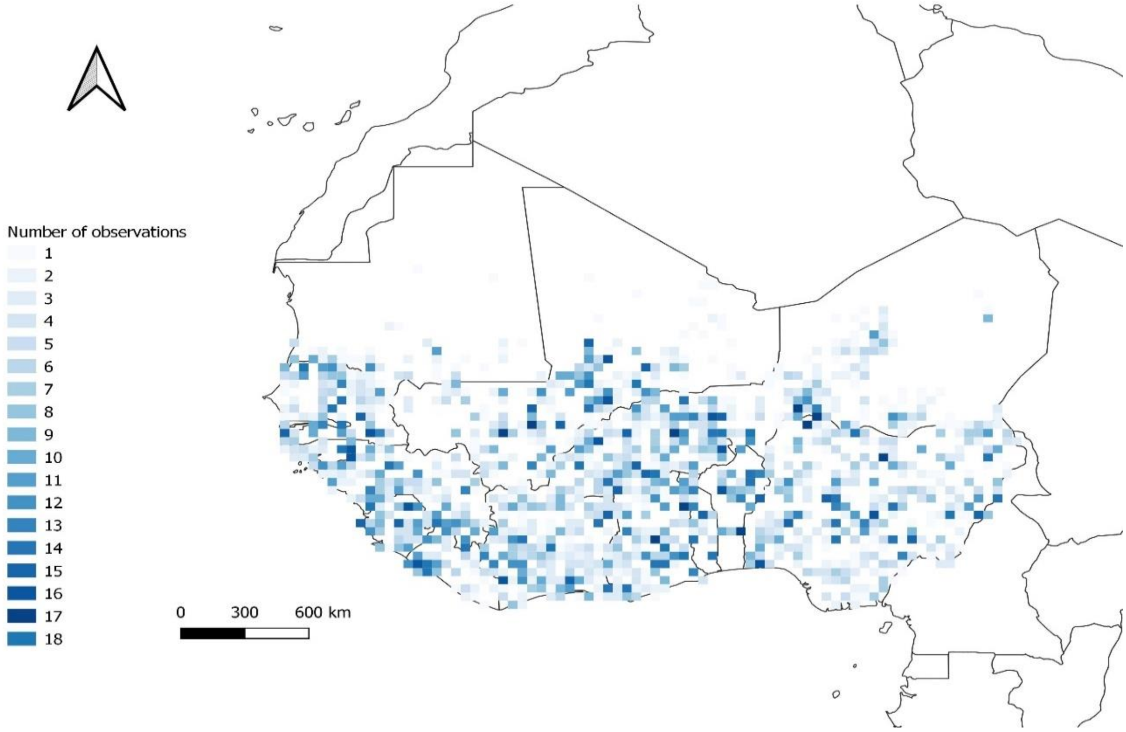

Fig. 3.1 Observed records of 102 priority CWR in West Africa

Analysis of the occurrence records showed that 18.5% (3,730) of the total unique present points were recorded in PAs. PAs with the highest number of taxa are Pendjari in Benin (28), Comoe National Park in Cote d' Ivoire (24), Niokolo – Koba National Park in Senegal (21), Quari Maro in Benin (18) and Queme Superieur in Benin (18), while PAs with the highest population of taxa are Sahel (708), Comoe National Park (407), Kouffe (250) and Pemdjari (239) (Table S1). 62.7% (64) of the priority taxa were represented in a PA, 34.3% (35) of the taxa were present in ≥5 PA, while the remaining 27.4% (28) had less than five populations in different PA (Table S2). However, 38 taxa (37.3%) did not occur in any PA. *Digitaria cilaris* (Retz) Koeler, *Vigna racemosa* (G. Don) Hutch, and *Eragrostis pilosa* (L.) P. Beauv., had the highest number of taxa populations in PA network with 443, 425 and 234 taxa population, respectively. Similarly, *Vigna racemosa* (G. Don) Hutch, *Eleusine indica* (L.) Gaertn. and *Oryza. glaberrima* Steeud. occurred in more PAs, appearing in 40, 38, and 37 PAs, respectively, while all the rice crop genepool occurred in the PA network. Cowpea (17), yam (13), and potato (9) crop genepools were the highest number of priority taxa that occurred in PA (Table 3S2). Nigeria, Benin, and Cote d'Ivoire had the highest number of PAs where taxa are present, with 46, 25, and 18 PAs, respectively. Conversely, no PA with taxa was identified in Mauritania (Fig. 3S2). Similarly, the highest number of taxa populations in PAs were found in Benin, Burkina-Faso, and Cote d'Ivoire, with 1351, 768, and 463 populations, respectively. Also, Benin, Nigeria, and Guinea had the highest number of CWR in PAs, numbering 207, 87, and 76 taxa respectively (Fig. 3S3)). 38 taxa (37.3%) did not occur in any PA, similarly, none of the Sorghum, fonio, and yam wild relatives occurred in PA. Other taxa not represented in PA are *Echinochloa crus- galli* (L.) P. Beauv., *Gossypium herbaceum* var. *acerifolium* (Guill. & Perr.) A. Chev., *Ipomoea ochracea* (Lindl.) Sweet, *Manihot dichotoma* Ule, *Triticum turgidum* L. and *Vigna. unguiculata* subsp. *stenophylla* (Harv.) Marechal & al. (Table 3S2).

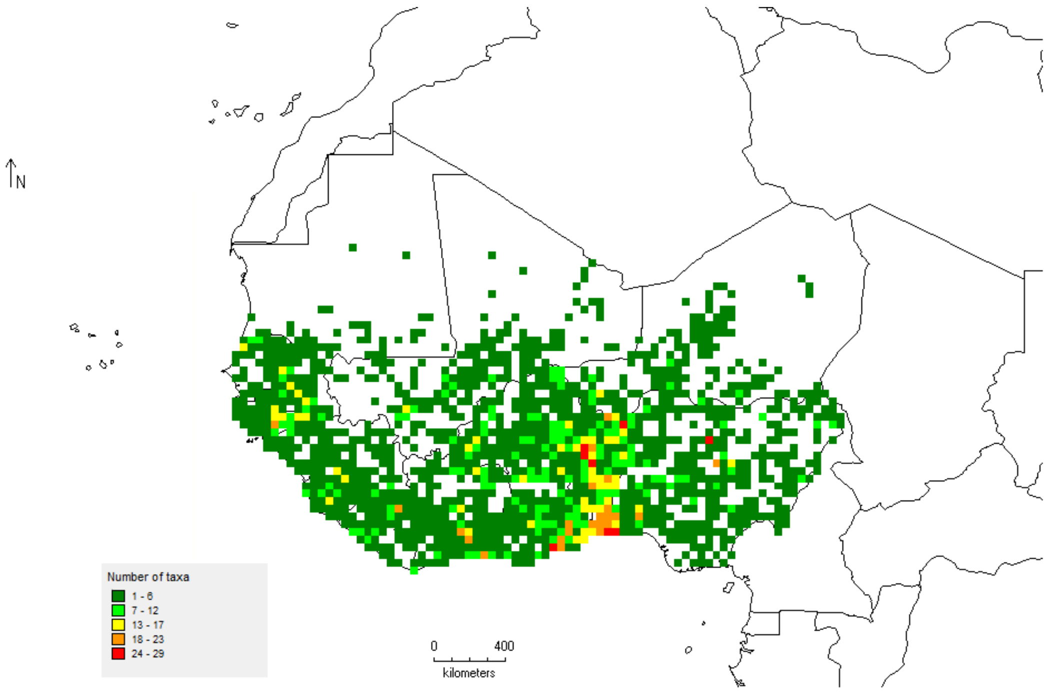

Fig. 3.2 Observed taxa richness map of 102 priority West African CWR

Complementarity analysis identified 29 potential genetic reserve sites with a grid square size of 0.4 degrees for the conservation of West African priority CWR (Fig. 3.3). Apart from Burkina–Faso, Liberia, Mauritania, and Gambia, genetic reserve sites were identified in all the other West African countries. The highest number of reserve sites were found in Nigeria with 9, while Benin and Guinea have 4 each (Fig. 3.3). Eleveen reserve sites are located in PA, with 9 of the sites conserving 37% (38) of the CWR, however, priority CWR were absent in Eleiyele and Volta River (Table 3S1 and 3S3). A total of 458 records were present in 9 reserve sites with taxa. 36.3% (37 taxa) of the priority CWR were found in the reserve sites (Table 3S3). *Vigna racemosa* (G. Don) Hutch. & Dalz, *Oryza glabarrima* Steud, *Vigna gracilis* (Guill. & Perr.) Hoof. f. and *O. barthi* A. Chev. had the highest number of taxa populations; 56, 51, 46, and 35 respectively in the genetic reserve sites (Table 3S2 and Table 3S5). Cowpea (10), yam (7), sweet potato (7), and rice (4), are the crop genepools with the highest number of CWR present in the reserve sites (Table 3S2 and Table 3S5). Conversely, cowpea (13), yam (8), sweet potato (6), and cassava (5) are the crop genepools with the highest number of taxa not represented in reserve sites. *V. racemosa* (G. Don) Hutch & Dalz., *O. barthi* A. Chev., *Ipomoea aquatica* Forssk., *O. longistiminata* A. Chev. & Roehr and *Eleusine indica* (L.) Gaertn were found in more genetic reserve sites than other taxa and were found in 4 reserve sites each (Table 3S3 and 3S5).

In situ conservation gap analysis of the 102 priority CWR showed that the areas of predicted distribution are present in all the West African countries (Fig. 3.4). The areas of highest potential diversity were found at Woroba and Montangnes districts of Cote d'Ivoire where some protected areas such as Mont Tia, Mont Sangbe, Pic de Fon, Pic de Tibe, Mt Yonon and Mont Nimba reserve site are located (Fig. 3.4). Also of high predicted CWR taxon richness are Nzerekore, Faranah, Kindia and Boke regions of Guinea where the Mont Nimba and Diecke reserve sites are situated. Other areas of high predicted taxon richness are in the South-South zone of Nigeria around Cross River National Park, North Eastern Nigeria, Kono and Koinadugu districts in Sierra Leone (Fig. 3.4), where these areas are predicted to harbor 51 to 63 CWR. However, areas from Abidjan in Cote d'Ivoire, Ghana, Togo, and Benin to South-West Nigeria had low areas of predicted distribution (Fig. 3.4). The ecogeographic diversity of 17 ELC zones are present in 152 PAs, while ELC zones 11 and 2 had the highest diversity in PAs (Table 3S4 and Fig. 3.6)

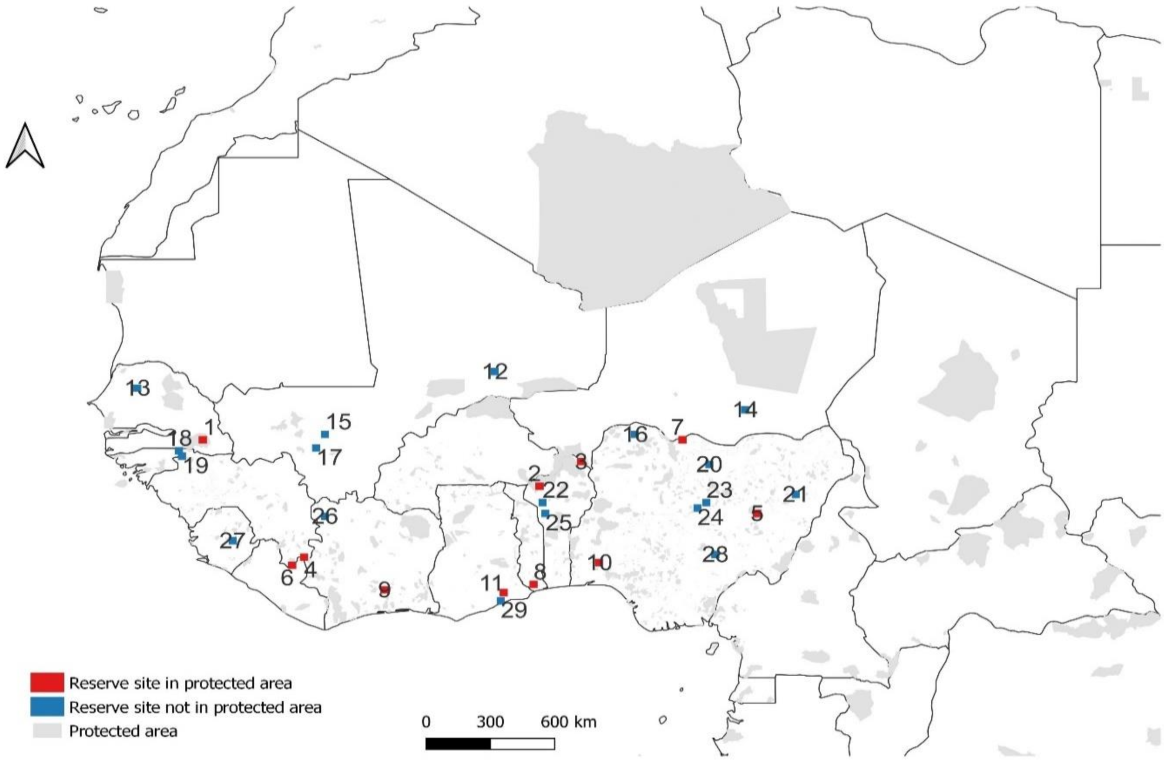

Fig. 3.3 Complementary analysis showing areas of proposed genetic reserve sites of West African priority CWR. Numbers are in order of conservation priority for the reserve sites. Grid cell size is 0.4 degrees, Geographic coordinate system is WCS 1984.

3.4.2 *Ex situ* gap analysis

The SDM of 55 taxa met the validation whereas for the remaining 8 CWR, a CA_{50} buffer area was created around each occurrence point (Table 3S6). The number of ecogeographic variables for the SDM varied from 15 in *Vigna filicaulis* Hepper and *V. desmodiodes* Wilczek to 43 in *Ipomoea aquatica* Forssk (Table 3S7 and Table 3.8). A total of 5720 (28.4%) accessions from 56 (55%) priority CWR are represented *ex situ*. 13 taxa had occurrence data but did not pass the validation criteria for the predicted distribution map (Table 3S6). 55% (56) priority CWR had at least one accession represented in genebank, of these, 23% (13) of the taxa had at least 50 accessions conserved *ex situ*, while 76.7% (43) of the accessions are underrepresented with less than 50 accessions conserved in genebanks. Nigeria had the highest number of accessions in genebanks, with 23.8% (1366) accessions, while Mauritania had the least 0.2% (13) (Fig. 3S1). Benin had the highest number of occurrence data (6428), while Mauritania had the least (150) (Fig. 3.1 and Fig. 3S1). *Oryza glabarrima* Steud, *O. barthi* A. Chev. and *O. longistaminata* A. Chev. & Roehr. had the highest number of accessions conserved in genebanks, with 2670, 610, and 562 accessions respectively (Table 3S2). All the *Hordeum* and *Phaseolus* CWR species had no occurrence data. Of the taxa that have occurrence data, 20 were not represented in genebanks, while *Cola nitida* (Vent.) Schott. & Endl. (3), *D. rotundata* Poir (3), *I. batatas* (L.) Lam. (3), *Sorghum bicolor* (L.) Moench (3) and *Vigna unguiculata* (Linn.) Walp. (3) represent the crop genepools with the highest number that was not present in both genebanks and PA (Table 3S9). Similarly, of the 13 taxa that did not occur in PA, 7 were not also represented in genebanks. However, all the taxa with ≥50 accessions in genebanks also occurred in ≥5 PAs (Table SS2 and Table 3S3).

The areas of further collection are found in all the West African countries (Fig. 3.7), while 87.27% (89) priority CWR needs further collecting (Table 3S2). Areas of further collection are the Assaba and Guidimaka provinces of Mauritania; Saint – Louis and Tambocounda regions in Senegal. Nzerekore region of Guinea; Koinadugu, Bombali and Tonkolili districts of Sierra Leone. Loffa, Bomi, Montserrado, and Grand Cape Mount counties of Liberia. Montagnes, Lacs and Lagunes districts of Cote d' Ivoire; Mopti region of Mali; Upper West, Bono East, Eastern, Volta and Ashanti regions of Ghana. Other areas are Haut – Bassins, Cascades, Est, and Centre–Est regions of Burkina Faso; Plateau, Queme, Atlantique, and Alibori provinces of Benin; North–East and North–Central zones of Nigeria (Fig. 3.7) Ecogeographic diversity of 16 ELC zones are conserved in genebanks (Table 3S9), while the CWR diversity of 8 zones is not represented. ELC zones 2,8 and 11 had the highest population which corresponds to the ELC map category. 50% of the ELC zones had ≥25% of their accessions represented in genebanks (Table 3S4), while ELC zones 2 and 11 had the highest collection.

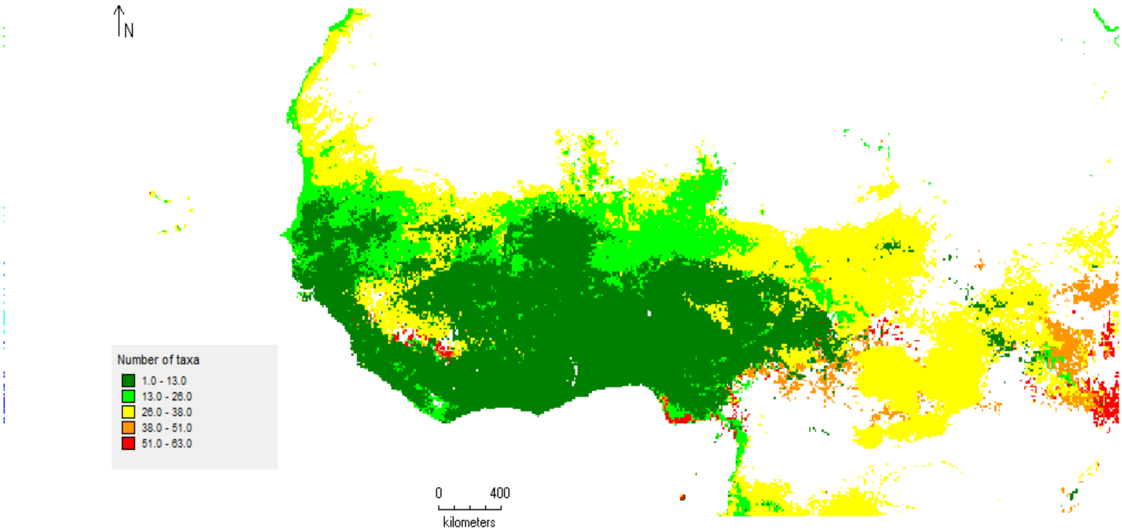

Fig. 3.4 Taxa richness based on predicted distribution of 102 priority CWR in West Africa.

Table 3.1 Reserve sites for *in situ* conservation of West African CWR and protected areas where they are located.

Reserve site	Protected Area	Total occurrence record	Number of CWR	ELC zones	Total area (Km^2)	Total area (ha)	country
1	Niokolo – Koba National Park	252	21	1,7	9,130	913000	Senegal
2	Boucle de la Pendjari	65	16	1	2755	275,500	Benin
3	Dosso	48	13	1,7	5,440.87	5.44,087	Niger
4	Mount Nimba	63	11	10,12	175.40	17, 540	Guinea
5	Yankari	24	9	1,4	2,254	225, 400	Nigeria

Reserve site	Protected Area	Total occurrence record	Number of CWR	ELC zones	Total area (Km^2)	Total area (ha)	country
6	Diecke	2	2	-	640	64,000	Guinea
7	Nasarawa	1	1	6	15,076,526	150,765.26	Nigeria
8	Eto	2	1	10	116.02	14.763	Togo
9	Goudi	1	1	10	96	9600	Cote d'Ivoire
10	Eleiyele	-	-	-	5.261	526.092	Nigeria
11	Volta River	-	-	-			Ghana

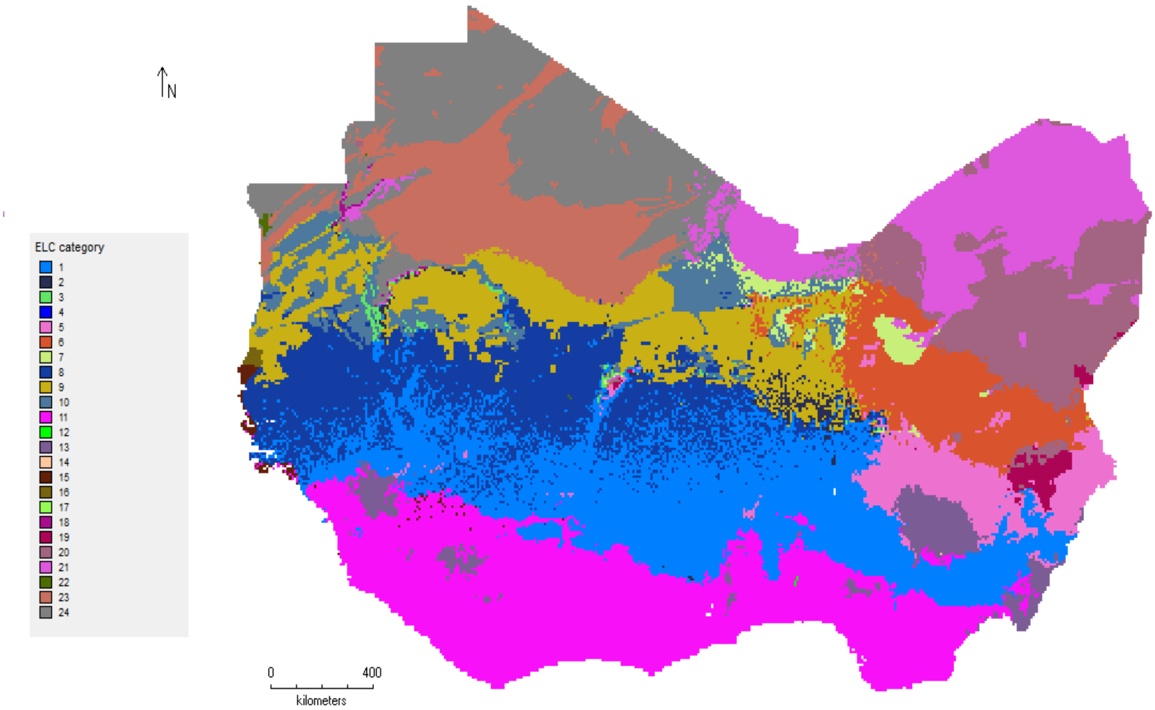

Fig. 3.5 Ecogeographic Land Characterization (ELC) generalist map of West Africa based on ecogeographic variables using the method described by Parra - Quijano *et al.* (2021).

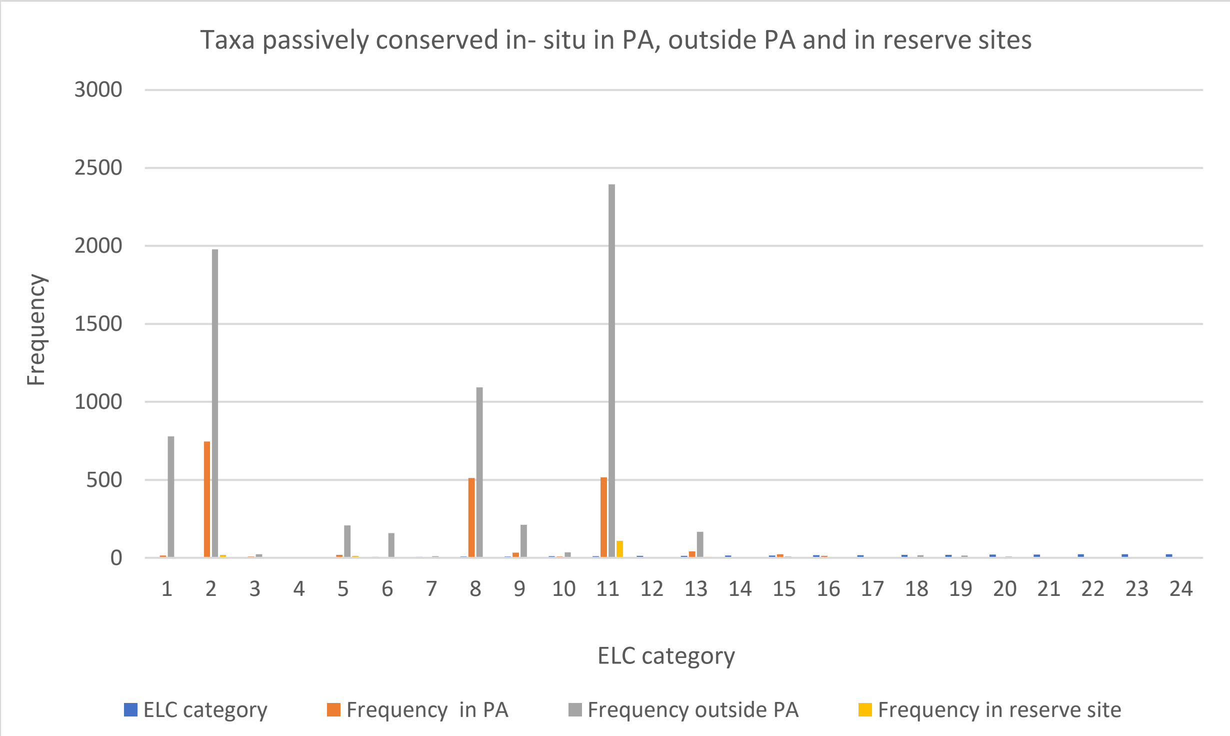

Fig. 3.6 *In situ* conservation gap of priority CWR based on taxa passively conserved in, outside PA, and reserve sites across the 24 ELC categories.

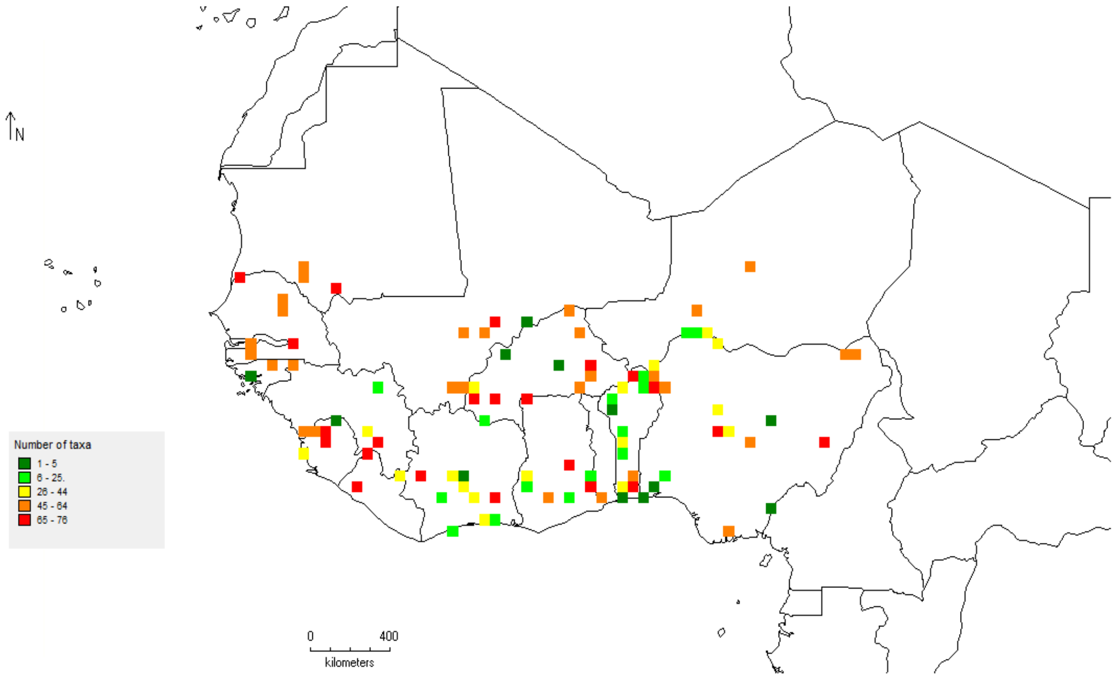

Fig. 3.7 Priority area for further *ex situ* collection of 102 West African priority CWR based on species distribution models.

3.5 DISCUSSION

West Africa is rich in taxa diversity, endemism, and biodiversity heritage, while CWR diversity and flora distribution of the region have been reported in various studies (Huchinson and Dalziel, 1958; Oates *et al.*, 2004; Bergl *et al.*, 2007; Idohou *et al.*, 2013; Hounsou-Dindin *et al.*, 2022). However, as a purpose of this, further study is needed to determine the gaps in *in situ* and *ex situ* conservation action in the region, as this will complement and consolidate the national efforts of the individual countries. According to a recent CWR ecogeographic diversity analysis, West Africa has been identified as a region of global importance with high CWR diversity for food security (Castañeda-Álvarez *et al.*, 2016; Vincent *et al.*, 2019). The highest CWR diversity identified in the provinces of Benin is because of the recent Flora of Benin (Akoègninou *et al.*, 2006), and the high number of occurrence records found in Benin, relative to other countries in the region (Figs. 3.1 and 3S1). High CWR diversity was also identified in the Accra and Volta regions of Ghana, North–Carral and South-Western zones of Nigeria. Other areas include Lacs district of Cote d' Ivoire and Nzerekore region of Guinea (Fig. 3.2). These areas correspond to some areas of predicted distribution such as Nzerekore region of Guinea where Mont Nimba, Diecke, Pic de Fon, Pic de Tibe Classified Forests are located (Fig. 3.4). Similarly, these areas of species richness are in congruence with the Guinean forest, categorized as one of the 36 biodiversity hotspots in the world (Maxted and Vincent, 2021; Vincent *et al.*, 2022), and the highest conservation value in Africa (Luiselli *et al.*, 2019). The Guinean Forest covers an area of 621,705 km^2, extending from Guinea, Sierra Leone, Liberia, Cote d'Ivoire, Ghana, Togo, and Benin to Nigeria. However, the Guinean Forest is one of the most exploited biodiversity hotspots in the world, though 15% of the original forest is still unexploited (Conservation International, 2007).

The network of PAs in West Africa conserves a substantial number of the priority CWR with 61% (63) of the taxa found in PAs (Table 3S2). However, further field surveys should be carried out to ascertain the presence of the priority CWR in those PAs where they were identified. For the 28 taxa (27.4%) that were found in less than five PAs, a field survey should be done in areas of predicted distribution to determine their locations and to identify more taxa populations in the network of PAs, to ensure they meet or surpass the required minimum number for active *in situ* conservation. Brown and Briggs (1991) and Dulloo *et al.* (2008) suggested the presence of five populations of taxa in different PAs as the minimum for *in situ* conservation in PA. Also, effective management and monitoring should be put in place to ensure active *in situ* conservation of the priority CWR in their respective PAs (Maxted *et al.*, 2008b). Relevant institutions, stakeholders, non – governmental organizations (NGOs), and protected area managers should synergistically, ensure the maintenance of the PAs for optimal and active conservation action. Pendjari National Park in Benin with an area of 2,765 km^2 and Comoe National Park in Cote d'Ivoire occupying an area of 11,500km^2 are the PAs with the highest number of

CWR (Table 3S1). The presence of more CWR in Pendjari National Park may have resulted from the fact that the site was better surveyed than other PAs, as shown in the number of occurrence data recorded in Benin as compared to other countries (Fig.s 3.1 and 3S1). UNESCO (2019) that 620 plant species are found in Comoe National Park, which agrees with the high number of CWR present in Comoe National Park. The site contains a great diversity of plants, endemic species, and diverse ecological habitats ranging from savannah, and forest to grasslands. (UNESCO, 2019). Large PAs such as Sahel (30,693 km^2), Comoe National Park (11,500 km^2), W National Park Benin (10,000 km^2), Niokolo – Koba National Park (9,130 km^2), were designed to conserve diverse ecogeographical populations, which CWR is a subset. However, they contain only a small of CWR population per unit area. The designation and development of the 18 reserve sites found outside PAs, as other effective based conservation measures (OECM) will augment the preservation of CWR population outside PA network (Iriondo *et al.*, 2021).

Identifying priority sites for the *in situ* conservation of CWR, based on species richness may be misleading since the approach relies only on taxa richness sites neglecting those taxa that require urgent protection (Brooks *et al.*, 2006). However, to overcome this challenge, complementarity analysis through reserve site selection is used (Fielder *et al.*, 2015; Contreras-Toledo, 2019; Mponya *et al.*, 2020). Complementarity analysis has been used to identify priority sites in regions such as the Southern African Development Commission (SADC) (Magos Brehm *et al.*, 2022) and the Middle East (Zair *et al.*, 2021). Twenty-nine reserve sites were identified in this study, with 11 in PA and 18 spotted outside PAs. The 11 reserve sites located in PAs will require minimal cost to establish and manage, being in existing PAs. It will augment and complement the protective function offered by the existing PAs and provide benefits to the local communities (Maxted *et al.*, 2008b; Maxted and Kell, 2009). The remaining 18 reserve sites not located in PAs also present an opportunity for those countries with low number of PAs where taxa were found such as Guinea – Bissau (3), Mali (4), Niger (5), Sierra Leone (7) and Senegal (9) (Fig. 3.3). The outcome of the complementary analysis showed that the location of some reserve sites corresponds with some CWR hotspots in West Africa. These areas are Atakora, Alibori, Donga, and Bongou provinces in Benin; the Accra region of Ghana; the North – Central and South–West zones of Nigeria and the Lacs district of Cote d' Ivoire (Figs. 3.2 and 3.3).

The areas of predicted distribution were highest in Woroba and Montangnes districts of Cote d'Ivoire where the reserve site; Mont Nimba is located and some protected areas such as Mont Tia, Mont Sangbe, Pic de Fon, Pic de Tibe, Mt Yonon are found. The area of high predicted distribution also extended to the Nzerekore, Faranah, Kindia, and Boke regions of Guinea, where the reserve site; Mont Nimba and Diecke Classified Forest are located (Fig. 3.4). Mont Nimba is strategic because it is located between Guinea and Cote d' Ivoire. It occupies a total land area of 175.4 km^2, with 125.4 km^2 in Guinea and 50 km^2 in Cote d'Ivoire. UNESCO (2019) reported diverse flora and endemic plant species on the site, including epiphytes and over 2000 vascular plant species. Similarly, Diecke Classified Forest is one of the largest undisturbed areas of the Guinee Forestiere with diverse plant species including several threatened tree species. The presence of *Cola attiensis* Aubrev. Pellegr. in the site (Table 3S3) was also reported by (Couch and Haba, 2021). The area of predicted distribution appears to be larger than the area of observed distribution, which shows that the region is under-surveyed. Efforts should be made for *ex situ* collection of taxa in predicted areas outside PAs, as they may be under threat by urbanization, change in land use, and habitat destruction (Mponya *et al.*, 2020).

For active *in situ* CWR conservation, effective *ex situ* conservation is needed to complement it. *Ex situ* conservation methods include seed bank, genebank, DNA bank, cryopreservation, botanical garden, and *in- vitro* conservation (Maxted *et al.*, 1997c; Maxted, 2013). 55% (56) of the priority taxa were represented in genebanks, however, more accessions need to be collected for *ex situ* conservation. Further collection actions should be undertaken for the 20 taxa with occurrence records but not present in genebanks, the 26 taxa without occurrence data, and the 44 taxa underrepresented in genebanks to reflect the recommendation by (Brown and Marshall, 1995) and (Guerrant *et al.*, 2004) of 50 taxa population for effective representation in genebank. Additionally, taxa already present in PAs should be conserved *ex situ* in genebanks as a backup to the *in situ* conservation to protect them in the event of natural disaster, war or fire outbreak (Ford-Lloyd and Maxted, 1993). Genebank accessions should be duplicated regionally and internationally to ensure effective and long-term *ex situ* conservation (FAO, 2014; Magos Brehm *et al.*, 2022).

The crop genepools with the highest number of taxa not represented in genebanks are yam (3), potato (3), sorghum (3), cowpea (3) and cola (3). Among the taxa that are not present in genebanks is *Dioscorea abyssinica* Hochst. ex. Kunth is used to improve yam for resistance against yam mosaic virus and anthracnose (Lopez- Montes *et al.*, 2012), *Manihot carthagenesis* (Jacq.) Mull. Arg, *M. dichotoma* Ule, *M. esculenta* subsp. *peruviana* Crantz and *M. esculenta* subsp. *flabellifolia* Crantz, used to improve resistance against cassava brown streak disease (Kawuki *et al.*, 2016). *Echinichloa frumentacea* Link and Eleusine Africana Kenn–O'Byne are used to breed Barnyard millet (Sood *et al.*, 2015) and finger millet (Dida and Devos, 2006), respectively for high yield. Other taxa that are not present in genebanks include *Phaseolus vulgaris* var. *aborigineus* (Burkart) Baude, used for the improvement of common beans against bruchid (Osborn *et al.*, 2003), white mold (Mkwaila *et al.*, 2011), web and bacterial blight (Beaver *et al.*, 2012) and for high-yield (Wright and Kelly, 2011). *Sorghum purpureosericeum* (Hochst ex. A. Rich) Schweinf & Asch. has confirmed used in the improvement of sorghum for resistance against sorghum shoot fly (Nwanze *et al.*, 1990), while *Sorghum bicolor* subsp. *verticiliforum* (L.) Moench is used in breeding sorghum for resistance against stem and leaf rust (Fetch Jr *et al.*, 2009;

Park *et al.*, 2015), increase in seed size and weight (Pillen *et al.*, 2004). *Hordeum bulbosum* L. is used in breeding barley for resistance against barley mild mosaic virus (Ruge *et al.*, 2003; Wendler *et al.*, 2015), barley yellow virus (Wendler *et al.*, 2015), powdery mildew (Pickering and Johnston, 2005; Johnston *et al.*, 2009), stem and leaf rust (Fetch Jr *et al.*, 2009; Johnston *et al.*, 2013; Park *et al.*, 2015) and leaf scald (Pickering *et al.*, 2006). *Ex situ* conservation will be a safety net for some CWR that have their adaptive scenario outside PA. For instance, some herbs and shrubs thrive on lawns, wastelands, swamps, and agricultural lands (Maxted and Kell, 2009).

A major objective of *in situ* conservation is to confirm and preserve diverse CWR genes in a defined location for optimal use in crop improvement to ensure food and nutrient security. Ecogeographical diversity can work as a proxy for genetic diversity (Korona, 1996; Parra-Quijano *et al.*, 2012a). The frequency of ecogeographical diversity outside PAs is higher, compared to that in PA. Therefore, *ex situ* collection of priority CWR outside PAs will capture taxa in ELC zones not represented or underrepresented in the network of PA. The ELC map shows all resilient environmental conditions present within the geographical location of the target taxa population. ELC zone 2 had more accessions in genebanks and the highest frequency of occurrence in PA compared to other ELC categories (Table 3S4 and Fig. 3.6). However, taxa found in rare ELC zones present unique genes (Contreras-Toledo, 2019; Parra - Quijano *et al.*, 2021) and should be prioritized in *ex situ* collection and conservation for use in crop improvement of their related crops. Complementarity analysis showed that 11 ELC categories were present in the reserve sites within PA, compared to 15 ELC categories represented in all PAs. This shows a high degree of complementarity in capturing the ecogeographical categories diversity of the priority CWR. On the average, the diversity of ELC categories per taxa was higher (26. 3%) compared to that for all PA network (23.4%) (Table 3S4). For ELC zones 12,14,16,17,19,22,23,24 where taxa were not represented in genebanks and ELC zones 4,7,20,21 with low genebank representation, based of frequency of occurrence (Table 3S9), further collection action should be carried out to ensure their representation. Similarly, *ex situ* collection should be done to represent all the ELC zones and ensure the preservation of novel and vital genes (Rubio-Teso *et al.*, 2013; Parra - Quijano *et al.*, 2021). The presence of these taxa in different ELC zones helps to identify those that thrives in adverse and marginal environments, as they may possess profitable genes for adapting their related crops to erratic climatic conditions (Garcia *et al.*, 2017).

3.6 RECOMMENDATIONS

Based on the outcome of this study, the following recommendations for the *in situ* and *ex situ* conservation of West African priority CWR are proposed:

1. Improved the efficacy of reserve sites in PAs for active *in situ* conservation through effective management and monitoring of the target CWR to ensure long-term preservation. Small PAs should be expanded to ensure full and optimal conservation area and to include CWR diversity that occurs next to them. The eleven reserve sites in PAs should be prioritized for the *in situ* conservation of West African priority CWR. Ascertain the suitability of the location of the 18 reserve sites that are not in PA, including the topography, accessibility, and demography of the taxa in the area. Then initiate the establishment of reserve sites for the *in situ* conservation of priority CWR not conserved in PAs, to augment the functions of existing PAs. New PAs are crucial for countries with limited PAs such as Guinea – Bissau, Mali, Niger, Sierra Leone, and Senegal (Fig 3S2 and Table 3S1). The identification of the 29 reserve sites is significant and a footprint for the *in situ* conservation of the priority CWR.
2. Conduct a field survey for the 38 taxa that did not occur in PA to ensure they are present in at least five PAs to meet the minimum number of representations in PAs for active *in situ* conservation (Dulloo *et al.*, 2008). Priority PAs for further field survey are those where CWR are predicted to be present such as Mont Tia, Mont Sangbe, Pic de Fon, Pic de Tibe, Mt Yonon, Cross River National Park, and reserve sites such as Mont Nimba and Diecke. Attention should be given to CWR diversity and general biodiversity present in reserve sites located in PAs to ensure the conservation of all available plant genetic diversity.
3. Maintain international genebanks in West Africa such as the International Institute of Tropical Agriculture (IITA) (IITA, 2022), Nigeria which conserve accessions of African food crops, AfricaRice M'be Cote d' Ivoire with over 22, 000 accessions (CGIAR, 2022) and ICRISAT, Niger (ICRISAT, 2022). Establish national genebank in the areas with high *ex situ* collection and predicted distribution for the *ex situ* conservation of priority CWR, while national genebanks like National Centre for Genetic Resources and Biotechnology (NACGRAB) Ibadan, Nigeria with 13, 839 accessions (Crop Trust, 2022), National Agricultural Research Center, Cote d' Ivoire holding 8,000 accessions of coffee (World Coffee Research, 2021) and Ghana National Genebank should be upgraded to hold more accessions. Also, genebank accessions should be duplicated in different facilities, while accessions present only in genebanks outside West Africa should be retrieved from international genebanks (Table 3S10) and conserved in areas where the taxa have their intrinsic features and taxon richness.
4. Search for occurrence data for the 26 taxa without occurrence records and for those with less than 10 records in their countries of endemism. Conduct field surveys for countries with inadequate occurrence data such as Mauritania, Gambia, Guinea–Bissau, Liberia, Togo, and Sierra Leone (Fig. 3S1), to identify the location of more priority CWR and taxa population both

within and outside PAs for *ex situ* collection and active *in situ* conservation. SDM and buffer CA_{50} can serve as a guide in locating the taxa in the areas of predicted distribution.

5. Prioritize the *ex situ* collection of the 43 taxa with less than 50 accessions in genebanks, using the SDM and CA_{50} as a guide to ensure their effective representation *ex situ*. Also, of priority are the 13 taxa with occurrence data that did not pass the validation criteria. Diversity in *ex situ* conservation should be increased to include seed banks, cryopreservation, *in – vitro* storage for recalcitrant taxa, and a botanical garden. Government agencies, institutions, local communities, and national and international genebanks should be involved in the collection mission.
6. Conduct field survey to identify priority CWR in the ELC zones with low frequency to ensure that a full range of ELC zones are captured to preserve unique and novel genes for use in crop improvement (Parra - Quijano *et al.*, 2021).
7. Make crosses between plants from collected seeds and their related crops, as well as between CWR found in PA and their related crops based on genepool levels (Table 3S11). Advanced methods such as embryo rescue, *in - vitro* gene transfer can be used for CWR that shows difficulty with conventional methods. This may help in resolving the challenge of hunger and food insecurity in the densely populated West African region.
8. Periodic revision, review and upgrade of the outcome of this study and the recommendations in the event of change in conservation priorities as a result of availability of more occurrence records and a more precise algorithm for ecogeographic modelling and occurrence data analysis.

3.7 CONCLUSION

This study evaluated the in situ and *ex situ* conservation gaps for the 102 West African CWR. The 26 taxa without occurrence data, 20 taxa with occurrence records but not present in genebanks, and the 43 taxa underrepresented in genebanks have been prioritized for further *ex situ* collection to ensure their effective representation in genebanks. The areas of high predicted distribution within PAs such as Mont Tia, Mont Sangbe, Pic de Fon, Pic de Tibe, Mt Yonon, Cross River National Park, and reserve sites such as Mont Nimba and Diecke were also prioritized for *ex situ* collection. The 38 taxa that are not present in PA and the 28 taxa with less than five populations in different PAs were also target taxa for identification and *in situ* conservation action. The establishment of the 29 identified reserve sites will further strengthen the CWR *in situ* conservation effort at the national and regional levels. Similarly, filling the identified *in situ* and *ex situ* conservation gaps will ensure that the priority CWR and agrobiodiversity are available for food, feed, and fiber use. Additionally, implementing the proposed recommendations will enhance the active conservation and sustainable utilization of the priority CWR for crop improvement to mitigate climate change and underpin food security for the rising population in West Africa.

CHAPTER 4

GLOBAL GENEPOOL CONSERVATION AND USE STRATEGY FOR *DIOSCOREA* (YAM)

The work presented in this chapter has been accepted for publication.

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4.1 ABSTRACT

The global genepool conservation and use strategy for yam was developed in this study. Diversity analysis, and *in situ* and *ex situ* conservation gap analyses were carried out for the 27 global priority yam crop wild relatives (CWR) at taxon and ecogeographic levels to determine their representativeness in conservation actions. Hotspots were found in Nzerekore region of Guinea, Nimba and Grand Gedeh regions of Liberia, Montagnes, Sassandra- Marahouse, and Bas – Sassandra regions of Cote d'Ivoire, Volta, Greater Accra and Eastern regions of Ghana, Centrale, and Plateau regions of Togo, Donga, Oueme, Athlantique, Littoral and Plateau provinces of Benin, South - West zone of Nigeria, Es region of Cameroon, Sangha- Mbaere region of Central Africa Republic. Likouala and Sangha regions of Congo, and Shan province of Myanmar and Thailand. A total of 13 potential reserve sites were identified in 13 countries, with four locations in the network of PA. 22 priority CWR (81%) were conserved *ex situ*, but only 15.38% of the taxa had at least 50 accessions in genebanks, and 65.38% of the priority CWR are underrepresented in genebanks, and 19.23 % of the species are not represented in *ex situ* collections. The findings and recommendations of this study will guide the production and implementation of effective long-term conservation action and sustainable utilization of globally priority yam CWR. The active conservation of the global yam priority species will underpin food security and climate change adaptation.

Keywords: Crop wild relatives, genebank, protected area, *in situ* and *ex situ*

4.2 INTRODUCTION

Yams are important nutrient-dense food crops (Danquah *et al.*, 2022). They are starchy staple food for many people across the globe, especially in tropical and subtropical countries. A total of 75.14 million tonnes of yams were harvested in 8.68 million hectares of land in 2021, with Nigeria, Benin, Ghana, and Cote d' Ivoire contributing to about 93% of the total production. West Africa accounted for 8.1 million hectares (94.4%) of the total area harvested in the same year (FAOSTAT, 2021). Yams are the second most economically valuable root and tuber crop, only ranked behind potatoes. It is predominantly used as food, providing proteins and micronutrients such as vitamin C and potassium. Yams are also processed into flour or starch for domestic and industrial purposes (Wanasundera and Ravindran, 1994). They contain active chemical constituents for pharmaceutical products, while bitter yam [*Dioscorea dumetorum (*Kunth) (Pax)] is used for the treatment of diabetes, due to its blood sugar-lowering ability (Andres *et al.*, 2017).

Yams (Dioscorea spp.) belongs to the family Dioscoraceae, and include both wild and cultivated species, with over 600 recognized species (The Plant List, 2013; Cao *et al.*, 2021). Edible forms have been selected by farmers, users and by breeding programmes over the past centuries and are cultivated among the wild relatives. Their vigorous herbaceous forms were first domesticated in the Niger River Basin of the region and are currently cultivated in Africa, Asia, South America and Oceania (POWO, 2021).Yams are the most economically valuable crop in West Africa and different species of yam have different centres of origin; *D. rotundata* Poir*, D. alata* L. and *D. trifida* L.f. were domesticated in West Africa, Southeast Asia and tropical America, respectively (Harlan, 1992; Andres *et al.*, 2017). Edible yam species are vegetatively propagated using the tubers or sections of the tuber. Current threats from habitat destruction, intensive land management, drought, competition from invasive species and climate change are causing genetic erosion and even extinction of CWR (Vincent *et al.*, 2013; Magos Brehm *et al.*, 2017a), intensify the need for collection missions and more active conservation of the genepool (Vincent *et al.*, 2013; IUCN, 2021).

Crop wild relatives (CWR) are wild plant taxa closely related to crops with an indirect use as novel gene or allele donors to their related crops (Maxted *et al.*, 2006). They are a vital subset of plant genetic resources that provide profitable genetic diversity for crop improvement. CWR are socioeconomic valuable resources that are needed to maintain future food, nutrient and economic security (Magos Brehm *et al.*, 2017a). Yam CWR such as *Dioscorea bulbifera* L. has been used to confer genes for high yield in White Guinea yam (Saini *et al.*, 2016), *Dioscorea abyssinica* Hochst. ex Kunth has been used to transfer yam mosaic virus resistance in *Dioscorea rotundata* Poir (White Guinea yam), *Dioscorea alata* (Greater yam/Water yam) and *Dioscorea cayenensis* Lam (Yellow Guinea yam) (Kikuno *et al.*, 2011; Lopez- Montes *et al.*, 2012). *Dioscorea praehensilis* Benth has confirmed use for breeding anthracnose resistance in White Guinea yam (Lopez- Montes *et al.*, 2012). Maxted and Kell (2009) reported the transfer of novel traits from 185 CWR to their related crops. Pimentel *et al.* (1997) estimated the global monetary value of CWR contribution to improved crop yield at about USD 115 billion per annum (USD 207 billion in 2023).

Entire genepool conservation is important to maintain the breath of genes and alleles in a crop and its wild relatives to prevent genetic erosion and make adaptive diversity available to breeders. Conservation strategies involve both *in situ* and *ex situ* techniques. *In situ* conservation involves the recognition, designation, management and monitoring of a population in its natural habitat, where its natural features are located (Maxted *et al.*, 1997c). *In situ* conservation should be the major conservation technique, while *ex situ* conservation is a complementary method, acting as a backup and provision of access to the conserved resource (FAO, 2001; Heywood and Dulloo, 2005; Stolton *et al.*, 2006). *Ex situ* conservation involves the safeguarding of biological diversity outside their native habitat. It requires the identification, sampling, transfer, management and monitoring of target plant samples outside their natural habitat (Maxted *et al.*, 1997c). Although, some edible yam species have been prioritized for *ex situ* collection, conservation and documentation in recent years, the wild relatives of yams are inadequately represented in *ex situ* collections (GBIF.org, 2020; Genesys, 2020). Similarly, whilst there are handful of cases of *in situ* conservation of edible yam species (Scarcelli *et al.*, 2019; Sharif *et al.*, 2020; Sugihara *et al.*, 2020), *in situ* conservation of wild relatives are scarcely documented (Chaïr *et al.*, 2010).

This work aimed to develop global genepool conservation and sustainable use strategy for wild yam through (a) Identifying existing gaps in *ex situ* collection of yams and developing strategies to fill the gaps (b) Recommending a network of sites for active *in situ* conservation of global yam priority wild relatives (c) Supporting the sustainable utilization of global yam priority CWR to enhance global food provision.

4.3 METHODS

4.3.1 Compilation of the CWR Checklist and Prioritization

The wild yam checklist was compiled using the CWR checklist and inventory template (Magos Brehm, 2017) and based on the World Checklist of Selected Plant Families (WCSP) (https://powo.science.kew.org/), The Plant List http://www.plantlist.org, the Germplasm Resources Information Network (GRIN) https://npgsweb.ars-grin.gov/gringlobal/taxon/taxonomysearchcwr, Harlan de Wet CWR diversity (https://www.cwrdiversity.org/checklist/).

The CWR checklist was annotated to aid prioritization and yam wild relatives were prioritized based on the closeness of the wild relatives to their related crops, via the use of the genepool concept (Harlan, 1971). The yam CWR checklist was prioritized based on a point scoring procedure and the level of scores was directly proportional to the degree of closeness to the crop species. The use of the genepool concept as the only criterion in the prioritization was to ensure the use of the priority CWR to improve their related crops. It will facilitate using the priority CWR as a resource for breeders in modifying crops to produce desirable cultivars. GP1b species were given the highest point (9) because of the ease of crossability of CWR with related crops. Secondary genepool (GP2) was given a score of 7, because of their relative ease of gene transferability. Conversely, GP3 were given a lower score due to the difficulty in gene transfer, without the application of sophisticated techniques. Only tertiary genepool (GP3) with proven use in crop improvement, were selected for prioritization (Ford-Lloyd *et al.*, 2008; Maxted, 2013) and given a score of three. Both the yam CWR checklist and priority list were sent for validation to experts from the International Institute of Tropical Agriculture, Ibadan in Nigeria, the Michael Okpara University of Agriculture, Umudike in Nigeria, and *Dioscorea* genus experts from the University of Abomy – Calavi, Cotonou in Benin.

The inventory of the priority yam wild relatives was completed with information on taxonomy, genepool, uses, distribution, the socioeconomic value of crops, threat status, biology and conservation status in the CWR checklist and data inventory template (Thormann *et al.*, 2017). The information was retrieved from the Germplasm Resources Information Network (GRIN) https://npgsweb.ars-grin.gov/gringlobal/taxon/taxonomysearchcwr, International Union for Conservation of Nature and Natural Resources (IUCN) https://www.iucnredlist.org/ , RainBio (http://rainbio.cesab.org/), Royal Botanical Garden Kew worldwide specimen data, World Checklist of Selected Plan Families (WCSP) http://wcsp.science.kew.org/cite.do. The Plant List http://www.plantlist.org, Global Portal on Plan Genetic Resources (GENESYS) https://www.genesys-pgr.org/, National Plant Germplasm System (NPGS) (https://data.nal.usda.gov/dataset/naional-plantgermplasm-system), Kew Herbarium Catalogue (http://apps.kew.org/hercat/gootlomepage.do), JSTOR Global Plants (http://plantsistor.org/), Missouri Botanical Garden worldwide specimen data, TROPICOS (http://www.tropicos.org/Home.aspx), African Plant Database (http://www.ville-ge.ch/musinfo/bd/cjb/africa/recherche.php?langue=an), New York Botanical Gardens (NYBG) Steere Herbarium https://sweetgum.nybg.org/science/ih/, Board of Trustees, Royal Botanical Gardens Kew (http://www.powo.science.kew.org), International Institute of Tropical Agriculture (IITA).

4.3.2. Diversity Analysis of Priority CWR

4.3.2.1 Occurrence Data Collection, Quality Verification, Control and Overview

The occurrence data of the yam priority CWR were collated using the 'Occurrence data collation template v.1' (Magos Brehm *et al.*, 2017b) from the Global Biodiversity Information Facility (GBIF), Global Portal on Plant Genetic Resources (GENESYS) https://www.genesys-pgr.org/, RainBio (http://rainbio.cesab.org/), International Union for Conservation of Nature and Natural Resources (IUCN) https://www.iucnredlist.org/, the New York Botanical Garden (NYBG) Steere Herbarium https://sweetgum.nybg.org/science/ih/, The herbarium of Royal Botanical Garden, and via contacting *Dioscorea* genus experts.

Records without geographic coordinates but with collection site information were georeferenced with Google Earth (https://earth.google.com). Occurrence records with geographic coordinates not expressed in decimal degrees were converted using Canadensys (https://data.canadensys.net/tools/coordinates). Duplicate records were removed,(i.e, records with the same information but different sources or documented twice from the same source (Magos Brehm *et al.*, 2017a), while records that lay abnormally in erroneous locations were reviewed and georeferenced wherever possible. Occurrence records were further checked for spelling errors, and formatted and standardized to be used in the CAPFITOGEN 3 tool (Parra - Quijano *et al.*, 2021), i.e, based on the FAO- Bioversity Multi-Crop descriptors (FAO-BIOVERSITY, 2015). The occurrence records were verified using the 'TesTable' tool of CAPFITOGEN 3 to ensure it meets the required standard for other CAPFITOGEN3 tools analyses followed by the GEOQUAL tool to evaluate the quality of the geographic coordinates and accuracy of collection sites of the records. Only records with Totalqual of 60 to 100 were included in the analyses to exclude accessions with unreliable data and include accessions with scarce records (Parra - Quijano *et al.*, 2021).

4.3.2.2 Distribution, Hotspots and Complementary Analyses

The species richness and species richness rarefaction maps were created in DIVA-GIS 7.5 (Hijmans *et al.*, 2012), at a resolution of 10 X 10 km (approximately 5 arc minutes) The rarefaction technique evaluates species richness for a particular number of samples, based on a systematic plot of the number of species against samples; a rarefaction curve is generated by re-sampling at random and plotting the number of taxa observed per sample. Rarefaction analysis assumes that individuals within a habitat are similar, genetically close and evenly distributed. If all these assumptions are not reached, the outcome is biased.

Predicted distribution models were developed for the priority CWR with more than 10 occurrence records using the Maximum Entropy Algorithm (MaxEnt) (Table 4S1) (Phillips *et al.*, 2006), and a circular buffer of 50 km(CA50) (Hijmans and Spooner, 2001) around each occurrence for those taxa with less than 10 records, following the approach suggested by Magos Brehm *et al.* (2022). Model calibration was carried out by dividing the taxa distribution records of the priority CWR into training set (75% of total occurrence records) and test set (25%). Bioclimatic variable raster files were sourced from WorldClim2.1 (https://www.worldclim.org/bioclim), edaphic variable raster files, from ISRIC-World Soil Information (https://files.isric.org/soilgrids/), geophysical data were obtained as Digital Elevation Map (DEM) files from the National Aeronautic Space Administration (NASA) (https://www.nasa.gov). By using the Spatial Analyst Tools of the ArcMap 10.4.1 (ESRI, 2015), the ecogeographic variable raster files were re-sampled to equal cell size of 0.41666666667 m, clipped to the same extent, reprojected to the same grid (WGS – 84), and formatted to ASCII grid format. At the resolution of 10 X 10 km (approximately 5 arc minutes at Equator), variables of each ecogeographic component (bioclimatic, edaphic and geophysical) were selected for each taxon, using the Random Forest, followed by bivariate correlation analysis integrated in the SelecVar tool of CAPFITOGEN 3 (Parra - Quijano *et al.*, 2021). Only variables with weak correlation (p> value ≤ 0.34) or not correlated variables (p- value = 0) were used to produce the species distribution model for each taxon (Table

4S4). As recommended by Liu *et al.* (2005), maximum training sensitivity plus specificity threshold was applied. The validity of the models were assessed using three criteria; (a) average area under the test receiver operating characteristics curve [(ATAUC) > 0.7] (b) standard deviation of ATAUC (STAUC) < 0.15 and (c) the section of potential distribution area with a STAUC > 0.15, being < 10% were secured and used for assessing taxa predicted distribution as recommended by Ramírez-Villegas *et al.* (2010) and applied by other authors (Mponya *et al.*, 2020; Magos Brehm *et al.*, 2022). For a model to be valid, all three criteria had to be met. Alternatively, as recommended by Hijmans and Spooner (2001) predicted distribution were produced by the circular buffer method, using a radius of 50 km (CA50) around each present point. In this case, intersecting locations were not considered more than once.

Complementary analysis was undertaken to identify potential locations for *in situ* conservation of the priority CWR using DIVA-GIS 7.5 (Hijmans *et al.*, 2012), at a resolution of 10 X 10 km (approximately 5arc minutes). The World PA map was obtained from UNEP-WCMC (2019) and overlapped with the taxon richness map and complementary genetic reserve site map to assess the degree of passive *in situ* conservation of the priority CWR in the existing network of PA, to effectively preserve and maintain their genetic diversity and protect them from diseases, pest, grazing, exploitation, degradation, fragmentation, and fluctuation (Vincent *et al.*, 2019). The maps generated were processed in DIVA-GIS 7.5, QGIS 3.16.8 (QGIS-Development Team, 2021) and ArcMap 10.4.1 (ESRI, 2015).

4.3.2.3 Ecogeographic Land Characterization (ELC) map

Ecogeographic land characterization (ELC) maps are aimed at conserving taxa across all its adaptive range. It is used as proxy for within- species diversity in order to develop strategies to maximize the conservation of diversity within each species (Parra - Quijano *et al.*, 2021; Magos Brehm *et al.*, 2022). Ecogeographic diversity is used as a proxy for genetic diversity (Parra-Quijano *et al.*, 2012a; Magos Brehm *et al.*, 2022). To generate the species-specific ELC maps, ecogeographic layers were created for each taxon by cropping the global ecogeographic layers to the actual size of the native spatial distribution range, using the rLayer tool of CAPFITOGEN3 (Parra - Quijano *et al.*, 2021). The global ecogeographic layers were sourced from WorldClim 2.1 (https://www.worldclim.org/bioclim). This was done by inputting the taxon occurrence data in rLayer tool and using a buffer cropway of 300 km at a resolution of 10 X 10 km approximately (5 arc – minutes). SelecVar tool of CAPFITOGEN3 was then used to identify the most important variables for each taxon amongst the 29 ecogeographic variables (comprising 13 bioclimatic, 12 edaphic, and 4 geophysic) (Tables 4S5 and 4S6). The species-specific ELC maps were produced using the ELC mapas tool of CAPFITOGEN3, to ensure a more specific adaptive scenario for each of the priority CWR. The species specific ELC maps were generated using the cropped ecogeographic layers for each taxon with the kmeanbic method (Parra - Quijano *et al.*, 2021), at a cell size of 10 km X 10 km (approximately 5 arc – minutes). The kmeanbic method was used because the function in R, evaluates the clustering process used in the univariate analysis of major components. It involves the analysis of progressive clusters by using the major components filtered from the raw data as variables. For each cluster, the information measure is determined as a criterion of goodness of fit, used to calculate the ideal number of clusters.

4.3.3. Gap Analysis of Priority CWR

4.3.3.1 *In situ* gap analysis

The method described by Maxted *et al.* (2008b); Scheldeman and van Zonneveld (2010) and Parra-Quijano *et al.* (2012b) was adopted in this study. *In situ* gap analysis involves the evaluation of the best combination of sites for *in situ* conservation at both taxon and genetic levels. At the taxon level, the world PA map was overlapped with the occurrence data of priority yam CWR, using QGIS 3.16.8. Similarly, the world PA map was intersected with the passport data, using the 'join attribute by location' in the 'data management tool' of QGIS 3.16.8, to identify records within and outside PA network. The *in situ* conservation gaps were determined by evaluating the relative number of populations of taxa in PA compared to those outside PA (Contreras-Toledo *et al.*, 2019; Mponya *et al.*, 2020). At the ecogeographic level, to determine the level of representativeness of wild yam' diversity in PA, the Representa of CAPFITOGEN 3 (Parra - Quijano *et al.*, 2021) was used to identify the ELC categories represented in the network of PA based on the ELC map (Zair *et al.*, 2021).

4.3.3.2 *Ex situ* gap analysis

Gap analysis of *ex situ* conservation was also assessed at taxon and ecogeographic levels. At the taxon level, the map of observed *ex situ* collection was subtracted from the map of potential distribution to determine the current *ex situ* conservation gap. The Representa tool' of CAPFITOGEN3 was then used to determine the level of representativeness of the ELC categories in the germplasm collection (Parra - Quijano *et al.*, 2021). The map was processed in ArcMap 10.7 (ESRI, 2015), QGIS 3.16.8 (QGIS-Development Team, 2021) and DIVA-GIS 7.5 (Hijmans *et al.*, 2012) at a cell size of 10 X 10 km (approximately 5 arc minutes). The ELC map was classified into quartiles, based on the frequencies of the ELC map, using the ELC zones in the ELC map. The frequency categories were low, mid- low, mid-high and high. 'Null' was used to classify zones where occurrence data were absent. The gaps in *ex situ* conservation were obtained by comparing the diversity present in ex situ accessions with that diversity that occurs in the wild (Contreras-Toledo *et al.*, 2019).

4.4 RESULT

4.4.1 CWR Checklist Compilation and Overview

A total of 38 CWR taxa were compiled into the CWR checklist. A CWR is defined as related to a crop when it is within the GP1 to GP3 (with proven use in crop improvement). The number of CWR related to edible yam species are 17 for the Greater/water yam (*D. alata* L.), 5 for Aerial yam (*D. bulbifera* L.), 25 for Yellow Guinea yam (*D. cayanensis* Lam), 5 for Bitter yam [*D. dumetorum* (Kunth) (Pax.)], 5 for Lesser/ Asiatic yam (*D. esculenta* (Lour) Burkill), 12 for White Guinea yam (*D. rotundata* Poir.) and one for *D. trifida* L. (Fig. 4.1). Three CWR are nationally endemic to Madagascar and include *D. antaly* Jum. & H. Perrier, *D. inopinata* Prain & Burkill and *D. transversa* R. Br. Twenty-eight CWR (73.7%) are regionally endemic – 15 are endemic to Africa, 13 are endemic to Asia, while 7 are cosmopolitan (Fig. 4.2).

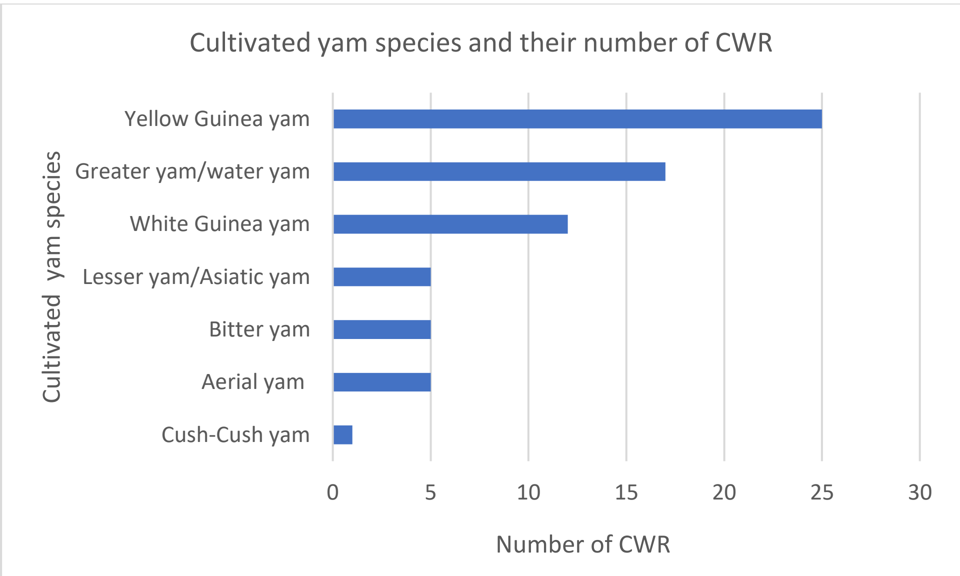

Fig. 4.1 Cultivated yam species and number of their priority CWR

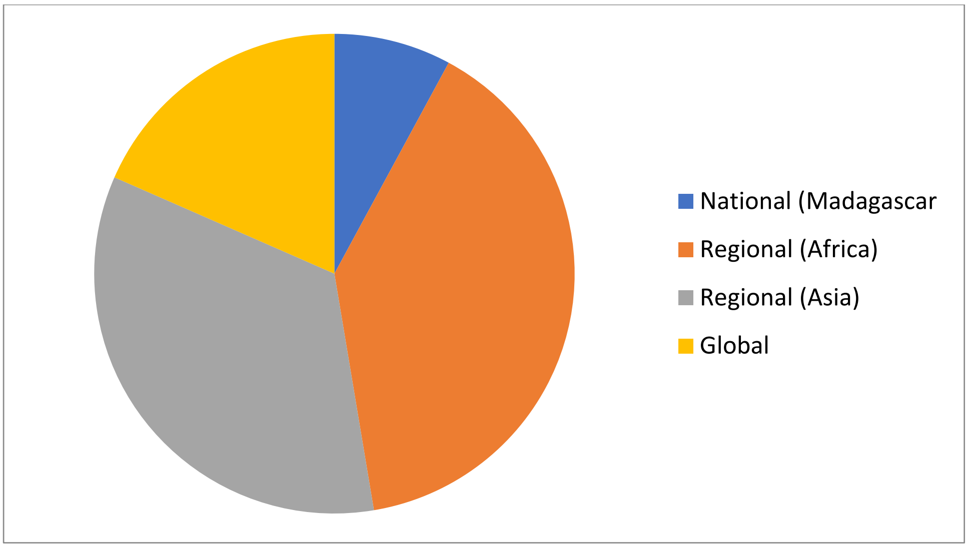

Fig. 4.2 Percentage of endemicity of global yam priority CWR

4.4.2 Priority taxa

Based on the criterion of genepool concept and validation of the experts consulted, a consensus was reached to prioritize 27 out of the 38 CWR taxa. Regarding the global threat status of the priority CWR, thirteen are Least Concern, two (*D. hamitonii* Hook. F. and *D. nummularia* Lam) are Near Threatened, one; *D. brevipetiolata* Prain & Burkill is Vulnerable, one (*D. pynaertii* De Wild) is Data Deficient, while ten are Not Evaluated (IUCN, 2023). Twenty-six of the priority CWR belong to the secondary genepool (GP2), *D. baya* De Wild and *D. burkillana* J. Miege belong to the tertiary genepool (GP3), and *D. hispida* Dennst belongs to the primary genepool (GP1b) (Table 4.1).

Table 4.1: Twenty-seven priority CWR, their related crops, genepool concept level and previous known uses in Crop Improvement

S/N	Crop	Priority CWR	Concept Level	Uses in Crop Improvement
1	Greater yam/Water yam (*D. alata* L.)	*Dioscorea brevipetiolata* Prain & Burkill	Secondary	
		Dioscorea calcicola Prain & Burkill	Secondary	
		Dioscorea cirrhosa Lour.	Secondary	
		Dioscorea decipiens Hook. f.	Secondary	
		Dioscorea glabra Roxb.	Secondary	
		Dioscorea hamiltonii Hook. f.	Secondary	
		Dioscorea inopinata Prain & Burkill	Secondary	

		Dioscorea lanata Bail	Secondary	
		Dioscorea nummularia Lam.	Secondary	Disease resistance (USDA, 2023)
		Dioscorea oryzetorum Prain & Burkill	Secondary	
		Dioscorea schimperiana Hochst. ex Kunth	Secondary	
		Dioscorea transversa R. Br.	Secondary	
		Dioscorea wallichii Hook.f.	Secondary	
2	Aerial yam (*D. bulbifera* L.)	*Dioscorea arachidna* Prain & Burkill	Secondary	
		Dioscorea pentaphylla L.	Secondary	
3	Yellow Guinea yam (*D. cayanensis* Lam)	*Dioscorea baya* De Wild	Tertiary	
		Dioscorea burkilliana J. Miege	Tertiary	
		Dioscorea praehensilis Benth.	Secondary	
		Dioscorea sagittifolia Pax	Secondary	
4	Bitter yam [*D. dumetorum* (Kunth) (Pax.)]	*Dioscorea antaly* Jum. & H. Perrier	Secondary	
		Dioscorea hispida Dennst	Primary	
5	White Guinea yam (*D. rotundata* Poir.)	*Dioscorea abyssinica* Hochst. ex Kunth	Secondary	Yam mosaic virus and anthracnose resistance (Lopez-Montes *et al.*, 2012; USDA, 2023)
		Dioscorea burkilliana J. Miege	Secondary	Growth habit and gene transfer (fertility) (USDA, 2023)
		Dioscorea mangenotiana J. Miege	Secondary	
		Dioscorea minutiflora Engl.	Secondary	
		Dioscorea praehensilis Benth.	Secondary	Crop quality and Disease resistance (USDA, 2023)
		Dioscorea pynaetii De Wild	Secondary	
		Dioscorea smilacifolia De Wild. & T. Durand	Secondary	
		Dioscorea togoensis R. Knuth	Secondary	

4.4.3 Diversity Analysis of Priority CWR

A total of 18,577 occurrence records were collated for the 27 global yam priority CWR, however, 8,812 records were retained after data verification and quality check was carried out. 6446 occurrence records were collated from GBIF, 2,116 from IUCN, 27 from GENESYS, 200 from RainBio, 20 from The Herbarium Catalogue, Royal Botanic Gardens, Kew, while two records were sourced from New York Botanical Garden (NYBG). The number of occurrence records for each priority CWR ranged from two to 2896. *D. transversa* R. Br., *D. praehensilis* Benth and *D. pentaphylla* L. have the highest number of records (1229), while *D. calcicola* Prain & Burkill, *D. inopinata* Prain & Burkill and *D. lanata* Bail have the least, two, six and eight, respectively (Table 4S1). Of the 8,812 occurrence records, 626 (7.10%) were genebank accessions (Table 4S2). These accessions were mainly sourced from the Thailand Institute of Scientific and Technological Research, Dodo Creek Research station (Solomon Island), Southern Regional Centre Laloki (NARI) (Papua New Guinea), International Crop Research Institute for the Semi- Arid Tropics (India), and Faculte des Sciences et Techniques (Benin).

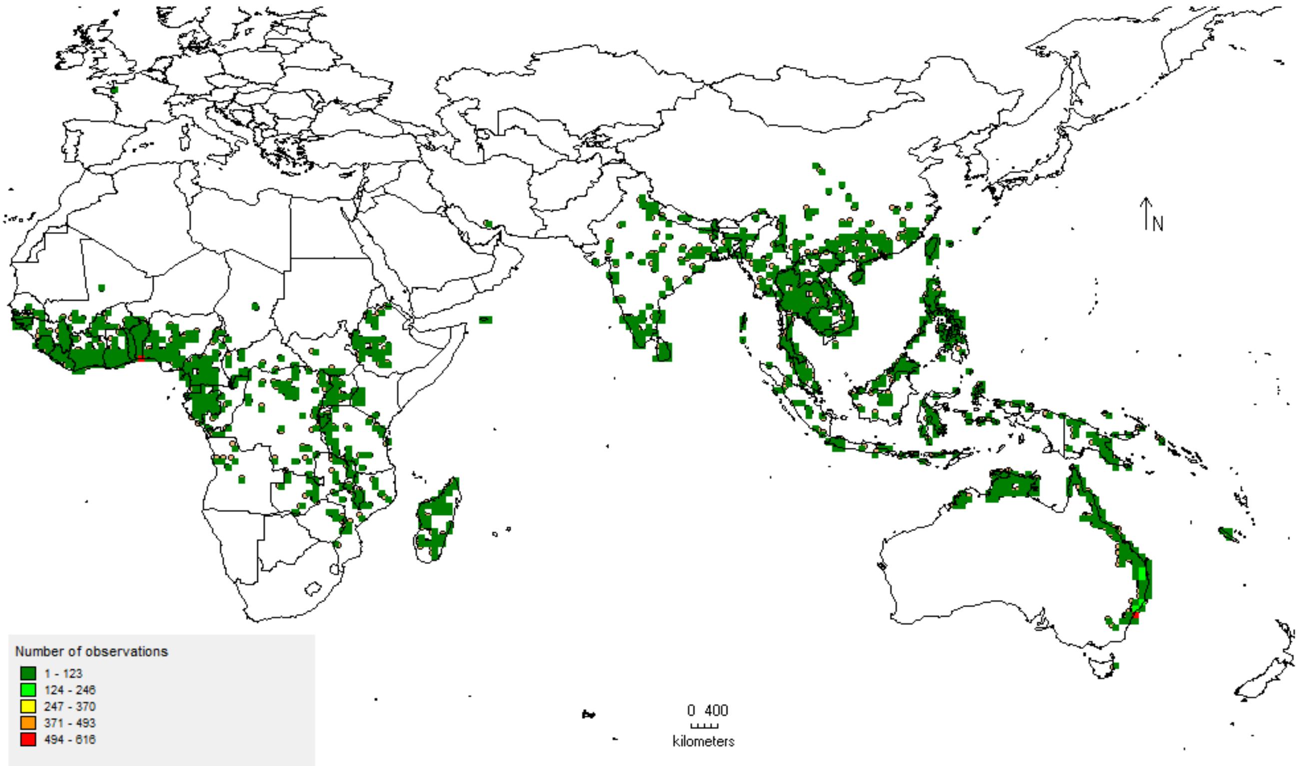

Fig. 4.3 Number of observations of the 27 priority CWR in Africa, Asia, and Oceania.

4.4.4 Diversity, hotspots, and complementary analyses

Species diversity hotspots were found in Nzerekore region of Guinea, Nimba and Grand Gedeh regions of Liberia, Montagnes, Sassandra- Marahouse, and Bas – Sassandra regions of Cote d'Ivoire, Volta, Greater Accra and Eastern regions of Ghana, Centrale and Plateau regions of Togo, Donga, Oueme, Athlantique, Littoral and Plateau provinces of Benin, South West zone of Nigeria, Es region of Cameroon, Sangha- Mbaere region of Central Africa Republic, Likouala and Sangha regions of Congo, and Shan province of Myanmar and Thailand (Fig 4.4). Species richness was highest in Thailand (Fig 4.5). Apart from Thailand in Asia, all the areas of hotspots diversity were in West and Central Africa.

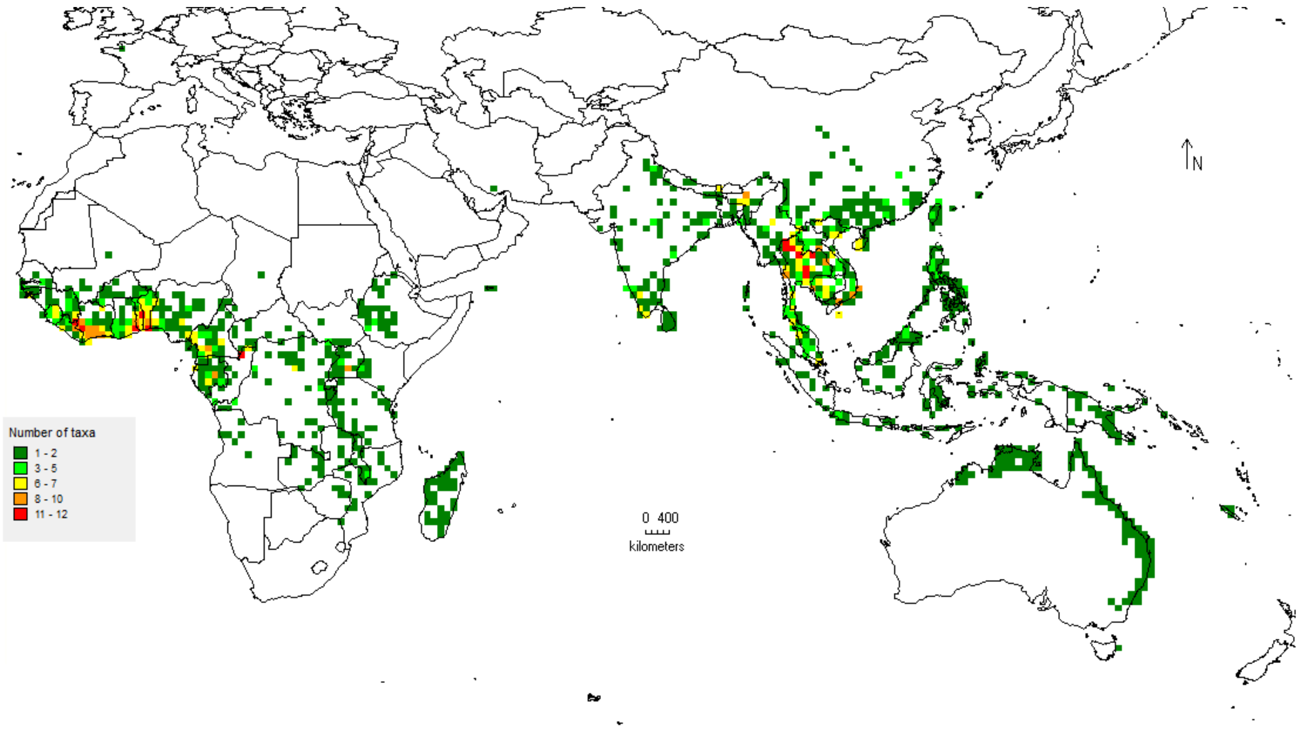

Fig. 4.4 Species richness of the 27 global yam priority CWR.

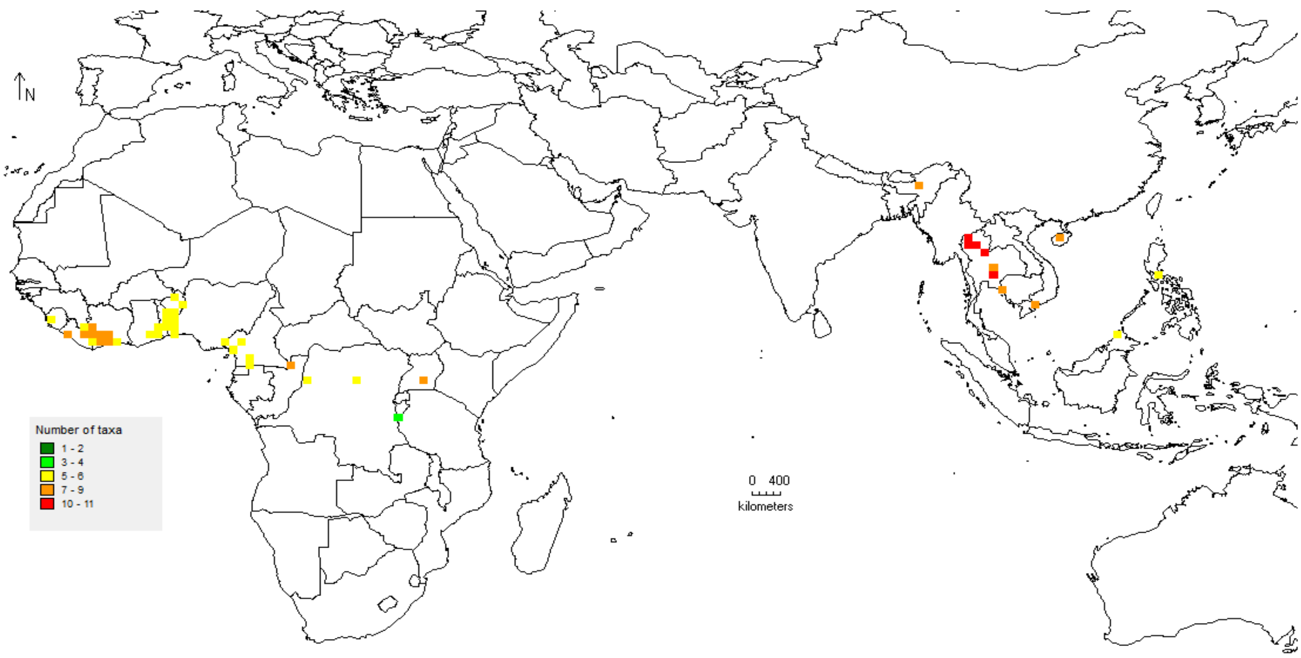

Fig. 4.5 Species richness rarefaction of the 27 global yam priority CWR

The number of ecogeographic variables used in the SDM ranged from 11 in *D. pynaertii* De Wild to 35 in *D. nummularia* Lam (Table 4S4 and 4S5). Based on SDM, areas of highest potential species diversity were found in Bas – Sassandra, Goh- Djiboua, Lagunes, Lacs, Comoe, Montagnes, Sassandra and Abidjan districts of Cote d' Ivoire, Western, Western North, Ashanti, Central, Eastern, Volta, Brong Ahafo, Ahafo, Bono Eas, Oti West and Greater Accra regions of Ghana, Mono, Oueme, Atlantique and Plateau provinces of Benin, South West, South- South and South East zones of Nigeria, Ogooue-Maritime, Moyen Ogooue and Ngounie regions of Gabon (Fig. 4.6), Thailand and Cambodia (Figs. 4.7 and 4.8). Most areas of predicted richness also correspond to the area of observed hotspots species diversity such as Lacs, Bas – Sassandra, Montagnes and Sassandra districts of Cote d'Ivoire, Volta, Accra and Eastern (Koforidue) regions of Ghana, Mono, Oueme, Littoral, Atlantique provinces of Benin (Figs. 4.4 and 4.6).

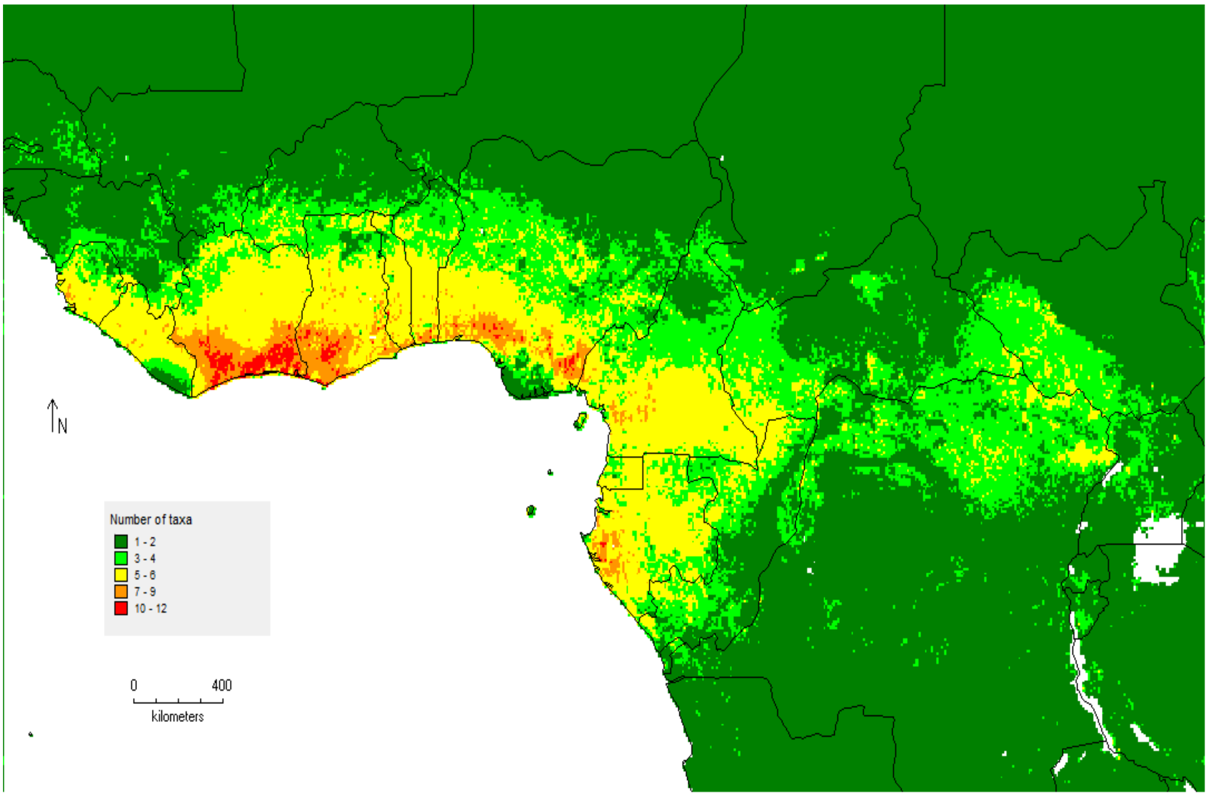

Fig. 4.6 Taxon richness based on predicted distribution of the 27 global yam priority CWR for Africa

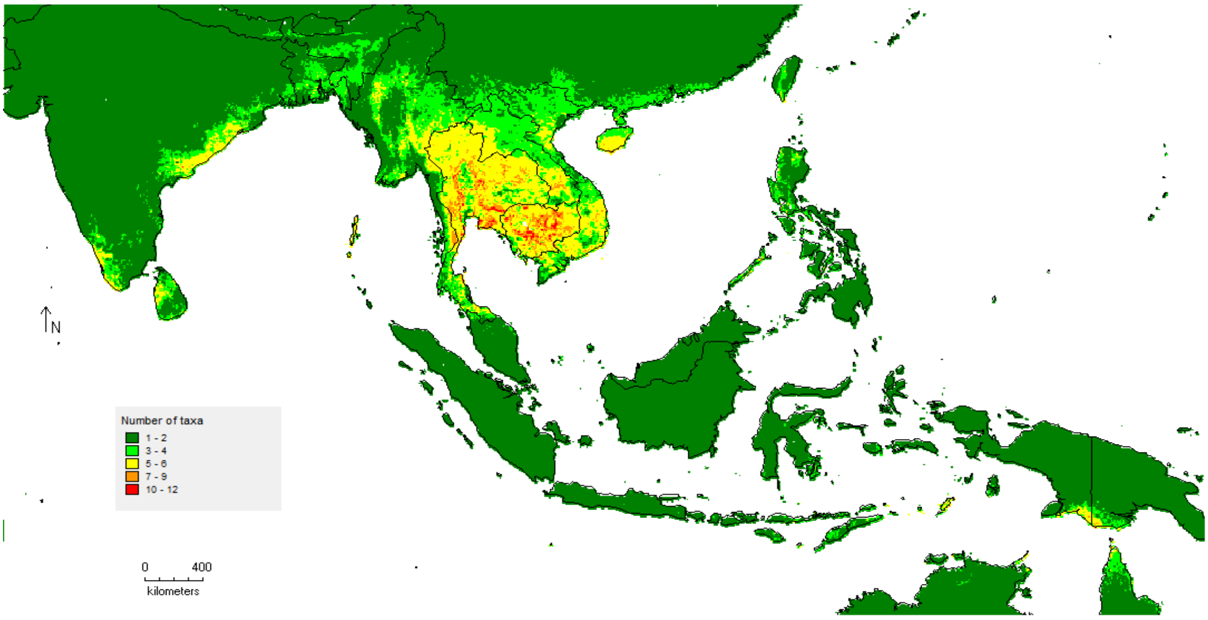

Fig. 4.7 Taxon richness based on predicted distribution of the 27 global yam priority CWR for Asia and Oceania

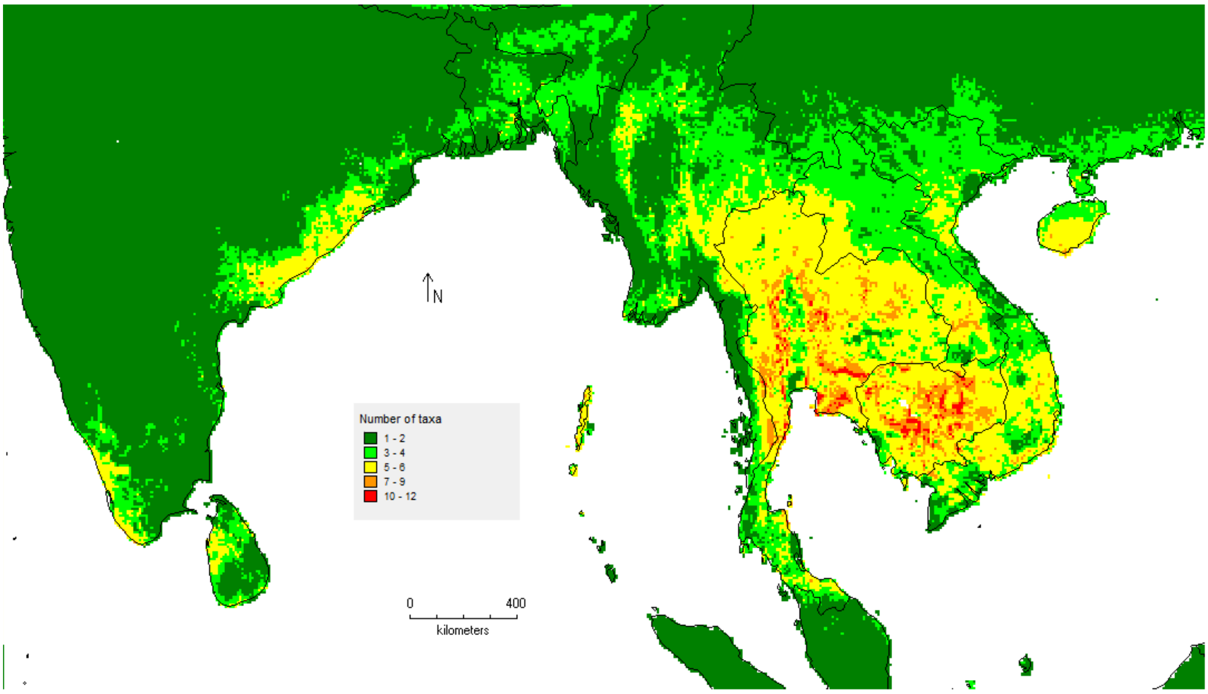

Fig. 4.8 Taxon richness based on predicted distribution of the 27 global yam priority CWR for Asia

A total of 13 complementary sites were identified to conserve all priority CWR. Out of these 13, four are located within existing network of PA, two in Asia, one in Africa and one in Oceania (Table 4.2, Fig. 4.9 and 4.10). Eight priority CWR were found in the complementary sites in PAs. The complementary sites not located in existing network of PA were found each in Ethiopia, Nigeria, Democratic Republic of Congo and Madagascar in Africa (Fig. 4.9), two each in India and Thailand and one in Malaysia in Asia (Fig. 4.10)

Table 4.2: Complementary sites in PA and the number of CWR and occurrence data recorded.

Number in maps	Protected area	Designation	Country	Number of priority CWR	Number of occurrence records	Priority CWR
1	Sangha Trinational	World Heritage site (natural or mixed)	Central Africa Republic	6	35	*D. baya, D. burkilliana, D. mangenotiana, D. praehensilis, D. schimperiana, D. smilacifolia*
2	Socotra Archipelago	World Heritage site (natural or mixed)	Yemen	1	6	*D. lanata*
10	Blue Fig Creek	Nature Refuge	Australia	1	1	*D. transversa*
11	Namtok Ched Sao Noi	Natural Park	Thailand	0	0	-

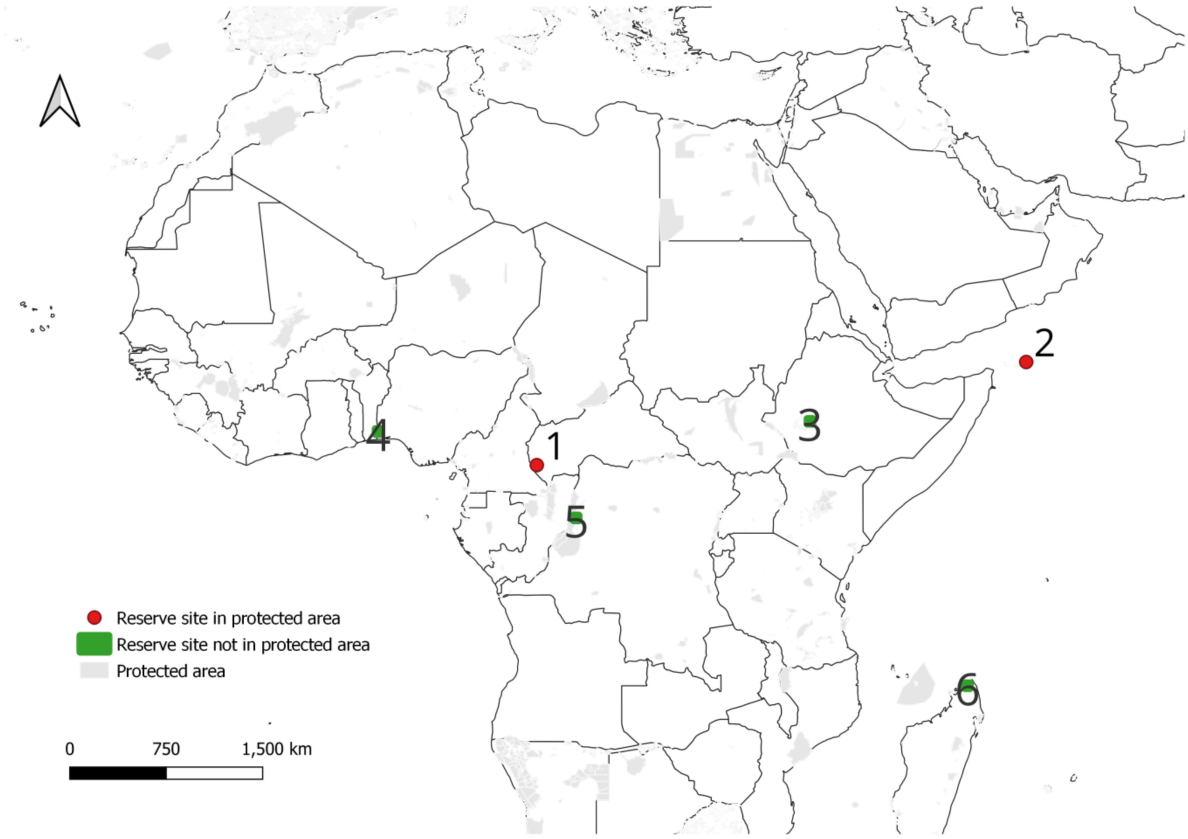

Fig. 4.9 Complementary analysis showing six potential sites for implementing genetic reserve for active conservation of global yam priority CWR in Africa. Grid cell is 50 X 50 km.

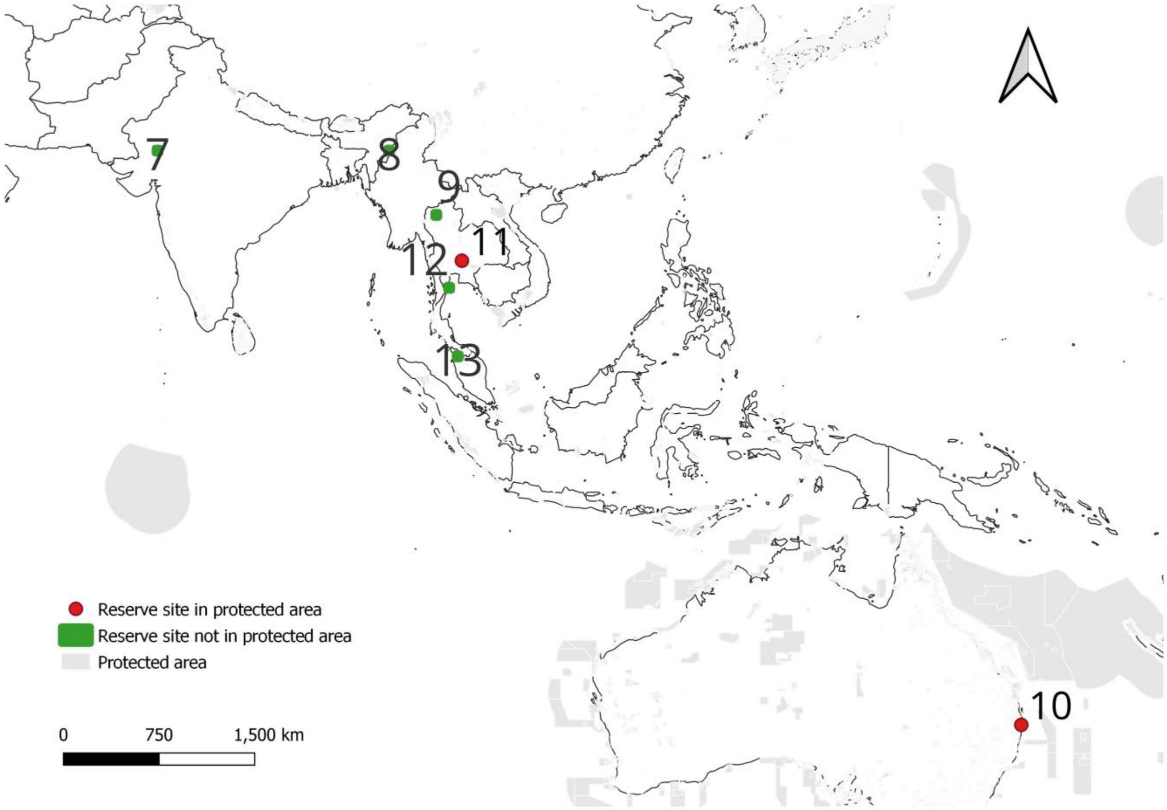

Fig. 4.10 Complementary analysis showing potential sites for implementing genetic reserves for active conservation of global yam priority CWR in Asia and Oceania. The grid cell is 50 X 50 km.

4.4.5 Ecogeographic Land Characterization (ELC) map

The number of ecogeographic variables used in generating the ELC maps ranged from 10 to 11 among the13 of the global yam priority CWR where ecogeographic diversity analysis were possible (Table 4S6). The number of ecogeographic categories ranged from 18 in *D. cirrhosa* Lour to 27 in *D. abyssinica* Hochst. ex. Kunth*, D. antaly* Jum. & H. Perrier and *D. baya* De Wild (Table 4S6). Based on the species specific ELC maps, the *ex situ* gap analysis showed that an average of 14.09% of the ecogeographic diversity of 13 of the global yam priority CWR for which ecogeographic diversity analysis was possible, is not conserved *ex situ* (Figs. 4S1 to 4S13, Table 4S7, 4S8 and 4S9). Similarly, 79% of the ecogeographic diversity of 13 of the 27 global yam priority taxa is not conserved *in situ* (Table S10). *Dioscorea schimperiana, D. praehensilis* and *D. hispida* have the highest frequencies of ELC categories in PA, while ELC categories 8, 7 and 11 have the highest total frequencies in PAs (Table 4S10). Similarly, *D. transversa, D. praehensilis* and *D. abyssinica* have the highest frequencies of ELC categories in *ex situ* collections, while ELC categories 11, 18 and 4 have the highest total frequencies *ex situ* (Table 4S8)

4.4.6 *In situ* gap analysis

Analysis of the occurrence data showed that 4.87% (430) of the total occurrence records were found in PA (Table 4S2). CWR were present only in three complementary sites in PA; Sangha Trinational, Socotra Archipelago and Blu Fig Creek (Table 4.2). The CWR present in the complementary sites in PA are *D. baya, D. burkilliana, D. mangenotiana, D. praehensilis, D. schimperiana, D. smilacifolia, D. lanata* and *D. transversa.* The CWR not found in PA are *D. antaly, D. calcicola, D. inopinata, D. pynaertii* and *D. sagittifolia* (Table 4S11). Two complementary sites in PA are found in Asia, while one each were in Africa and Oceania, respectively. Protected areas with the highest number of CWR populations are Sugarloaf (77), Yanganmbi (54) and Great Sandy (42). Dong Phayayen Khao Yai Forest Complex (7), Sangha Trinational (6) and Lamto Scientific Reserve (5) had the highest number of CWR (Table 4S11). Although six priority CWR did not occur in any PA, 10.8% (4) of the taxa were present in ≥ 5 PA, while the remaining 85.2% (23) were found in less than five different PA (Table 4S11). Similarly, 37.04 % (10) of the taxa had < 5 populations in network of PA (Table 4S2). *Dioscorea transversa, D. smilacifolia* and *D. minutiflora* had the highest number of populations in PA, with 427, 42 and 30 records, respectively (Table 4S11). Similarly, *D. transversa, D. smilacifolia* and *D. minutiflora* occurred in more PA, occurring in 37, 6 and 5 PA, respectively. Protected areas with yam wild relatives were found in 17 countries. Countries with the highest number of PA with taxa are Australia, with 37 PA, followed by Thailand, Guinea, and DR Congo, with three PA each. Population of priority wild yams were found in 60 PA. Australia, Congo (the Democratic Republic of) and Congo (the) had the highest number of populations in PA, with 247, 56 and 38, respectively (Table 4S12).

4.4.7 *Ex situ* gap analysis

The SDM of 23 priority CWR passed the validation criteria, however, for the other 3 taxa *D. inopinata* Prain & Burkill, *D. lanata* Bail and *D. pynaertii* De Wild, a CA50 buffer area was created around each presence point (Table 4S1). 15.38% (4) of priority taxa have at least 50 accessions in genebank, while 65.38% (17) were underrepresented in genebanks, with less than 50 accessions conserved *ex situ. Dioscorea praehensilis* Benth*, D. minutiflora* Engl. and *D. pentaphylla* L. have the highest number of accessions in genebanks, with 112, 70 and 60 accessions, respectively. Among all the countries with occurrence data, 34 countries have genebank accessions conserved *ex situ*. However, 19.23% (5) of the taxa are not represented in *ex situ* collections. These are *D. calcicola, D. inopinata, D. lanata, D. pynaertii* and *D. transversa.* Areas of further *ex situ* collection were identified in Mali, Liberia, Cote d' Ivoire, Ghana, Togo, Cameroon, Angola, Ethiopia, Madagascar in Africa (FIG. 4.11), India, Thailand, Lao People's Democratic Republic, Vietnam and Cambodia (Figs. 4.12 and 4.13). Only five taxa do not require further *ex situ* collection and include *D. glabra, D. hispida, D. minutiflora, D. pentaphylla* and

D. praehensilis, because they have at least 50 accessions represented in genebanks (Table 4S2). 81% (22) of the priority taxa were conserved *ex situ*, however, only 626 (7.10%) of the occurrence records represents genebank accessions (Table 4S2).

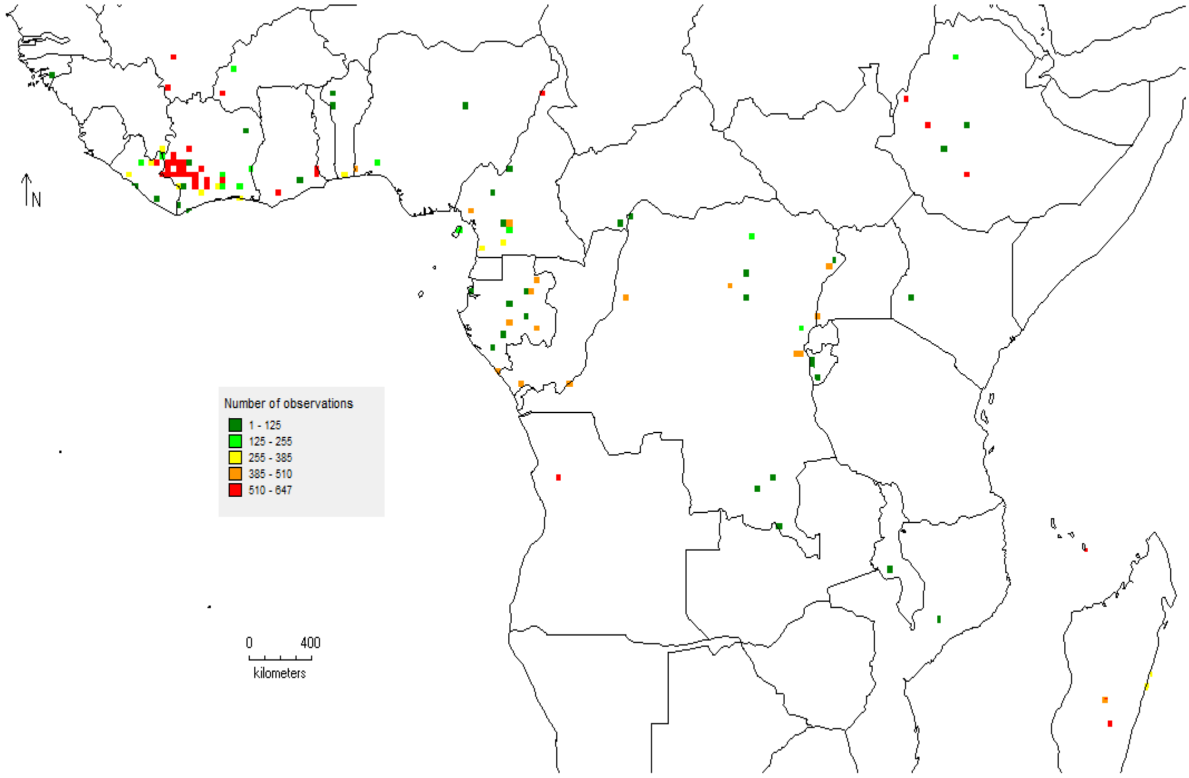

Fig. 4.11 Priority areas in Africa for further *ex situ* collection of the 26 global priority yam wild relatives, based of species distribution models.

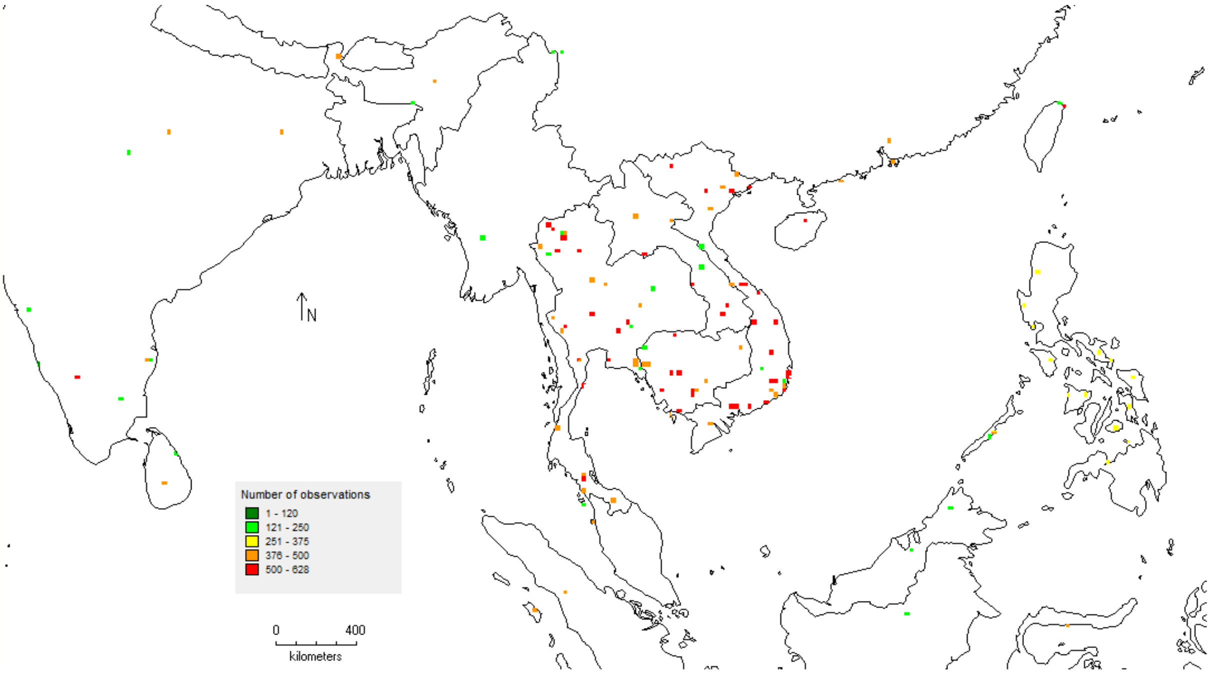

Fig. 4.12 Priority areas in Asia and Oeania for further *ex situ* collection of the 26 global priority yam wild relatives, based of species distribution models.

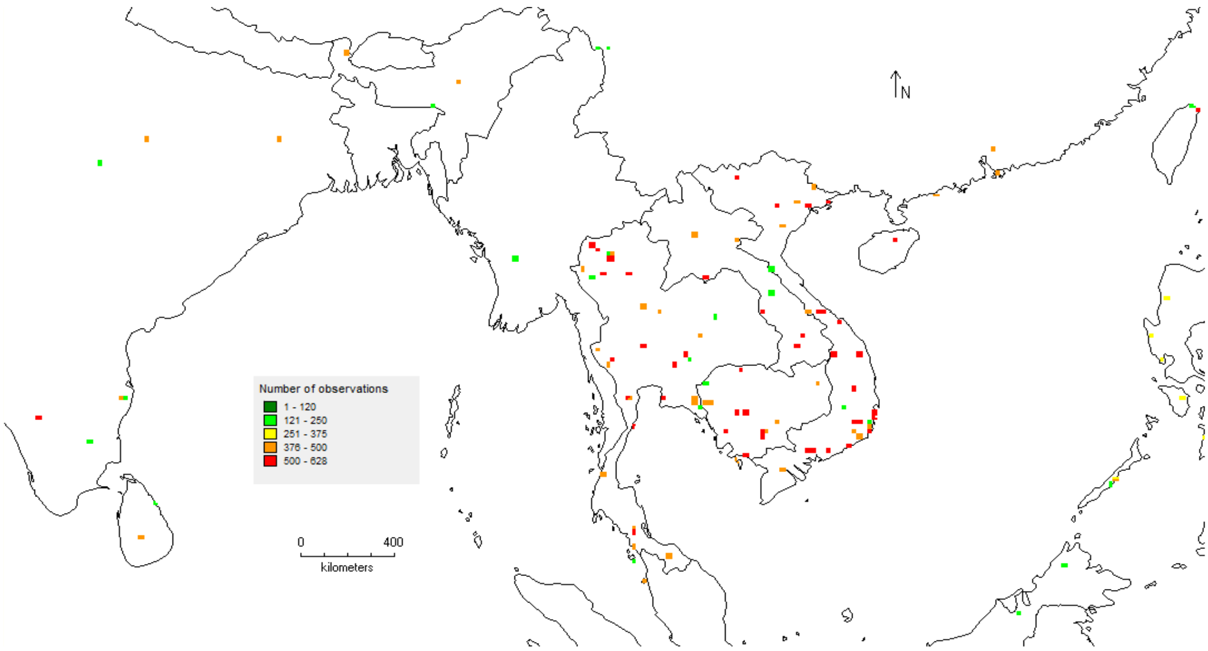

Fig. 4.13 Priority areas in Asia for further *ex situ* collection of the 26 global priority yam wild relatives, based of species distribution models.

4.5 DISCUSSION

The global yam genepool diversity comprises yam CWR endemic to Africa, Asia, Oceania, and cosmopolitan taxa. This study focuses on the development of a conservation strategy for global yam wild relatives. Our findings suggest there are existing *ex situ* conservation of global yam wild relatives, but major gaps still exist in *ex situ* collections and there is virtually no active *in situ* conservation. Therefore, the global yam genepool requires urgent active safeguarding to ensure its maintenance and availability for crop improvement (Maxted *et al.*, 2015; Mburu *et al.*, 2016). The highest number of observations and number of occurrences are found in Australia and Benin, and this is attributed to high level of occurrence data collection in recent years in the two countries. However, the lowest number of records were found in Eritrea, Niger, Chad and South Sudan. Field surveys should be conducted in these countries with few occurrence records to ensure adequate data are available for enhanced conservation planning.

The high priority CWR observed diversity, identified in some areas such as Montagnes, Sassandra – Marahouse, and Bas- Sassandra regions of Cote d' Ivoire, Volta, Greater Accra and Eastern regions of Ghana, Donga, Oueme, Athlantique, Littoral and Plateau provinces of Benin, South - West zones of Nigeria, Est region of Cameroon, Likouala and Sangha regions of Congo, Thailand is likely due to the relatively high number occurrence data associated with those areas. The areas of observed hotspot diversity are in this study congruence with the biodiversity hotspots of the world (Conservation International, 2008). The observed hotspot diversity areas in West Africa are within the Guinean forest, while the area in Thailand corresponds with the Indo-Burma, India and Myanmar biodiversity hotspots. These two diversity hotspots are among 36 biodiversity hotspots and agricultural centres of origin of the world (Conservation International, 2007). The Guinean Forest extends from Guinea, Sierra Leone, Liberia, Cote d' Ivoire, Ghana, Togo and Nigeria, while the Indo-Burma, India and Myanmar biodiversity hotspot spans from Myanmar, Thailand, Cambodia, Vietnam, India and China. To qualify as a biodiversity hotspot, an area must have at least 1500 endemic vascular plants and loss at least < 70% of its original vegetation (Hoffman *et al.*, 2016). Most areas of predicted distribution also correspond with the areas of hotspot diversity such as Lacs, Bas – Sassandra and Montagnes districts of Cote d' Ivoire, Volta, Accra and Eastern (Koforidue) regions of Ghana, Mono, Oueme, Littoral and Atlantique provinces of Benin (Figs. 4.4 and 4.6). Similarly, Namtok Ched Sao Noi, Natural Park, Thailand, a reserve sites in PA is located within the Indo-Burma, India and Myanmar biodiversity hotspots (Conservation International, 2007). For a comprehensive conservation of priority CWR, complementary analysis is required (Fielder *et al.*, 2015; Contreras-Toledo *et al.*, 2019). Complementary analysis has been used to identify priority locations in regions such as Southern Africa Development Commission (SADC) (Magos Brehm *et al.*, 2022) and Middle East (Zair *et al.*, 2021).

Establishment of the four complementary sites in PA and the other 9 outside PA will help strengthen the *in situ* conservation of the global yam priority CWR.

The identification of conservation gaps in the ecogeographic diversity of the global yam priority CWR will initiate and facilitate the germplasm collection *and ex situ* conservation of taxa with ecogeographic diversity gaps to ensure their effective representation in *in situ* and *ex situ* conservation (Magos Brehm *et al.*, 2022). *Ex situ* collection should be prioritized for *D. arachidna* Prain & Burkill*, D. cirrhosa* Lour*, D. schimperiana* Hochst. ex. Kunth found in few ELC categories and that of the 14 priority CWR where ELC map analysis were not possible. Similarly, the ecogeographic diversity of *D. hispida* Dennst. *and D. minutiflora* Engl. found in few ELC categories and that of the 14 priority CWR where ELC map analysis were not possible should be given priority for *in situ* conservation.

Complementary analysis was used to identify priority sites within existing PA for *in situ* conservation of priority CWR in regions such as; Southern Africa (Magos Brehm *et al.*, 2022), Middle East (Zair *et al.*, 2021) and West Africa (Nduche *et al.*, 2023). However, for yam CWR, the number of CWR not conserved in PA *in situ* is large (95.5%) (Table 4S11). This is inconsistent with the report by Magos Brehm *et al.* (2022) and Nduche *et al.* (2023), where only 19% and 37.3% of the regional priority CWR occurred outside the PA network. For the taxa not represented in PA, 23 taxa that had less than five populations in PA and the five priority CWR that did not occur in any PA, further field surveys should be conducted to discover if this is a true reflection of yam CWR occurrence. The taxa absent in PA include *D. antaly, D. calcicola, D. inopinata, D. pynaertii* and *D. sagittifolia*. Also, for the countries with occurrence data but without taxa in PA, more inventory programmes should be implemented as this is likely to increase the number of taxa in PA. Among the priority CWR found in PA are *D. abyssinica* and *D. praehensilis,* with confirmed uses in the improvement of White Guinea yam against resistance for yam mosaic virus (Lopez- Montes *et al.*, 2012) and potential use for adapting White Guinea yam and yellow yam to biotic stress (Kikuno *et al.*, 2011).

The number of CWR not already conserved *ex situ* is 5 (19%), is relatively low, compared to the number of germplasms represented in genebanks. This is inconsistent with the findings by (Zair *et al.*, 2021); Magos Brehm *et al.* (2022) and (Nduche *et al.*, 2023) where 30%, 50% and 71.6% of priority CWR were not represented in *ex situ* collections. Although these studies did not focus on yam. Similarly, FAO (2010) reported that about 15,903 accessions of yams and their wild relatives are conserved in 99 facilities of 57 countries. However, 81.4% (22) of the priority taxa require further *ex situ* collection, because of their low representation (< 5 populations) in genebanks. This entails an active collaborative collection programme from stakeholders such as genebank curators, plant breeders, protected area managers, conservation park rangers, farmers, and herbarium curators to ensure effective representation of the underrepresented taxa in genebanks. Priority should be given to those taxa not conserved *ex situ*, which are *D. calcicola, D. inopinata*, *D. lanata*, *D. pynaertii* and *D. transversa*, and in taxa where *ex situ* conservation gaps were identified at the taxon and ecogeographic diversity levels.

Based on the result of this work, the recommendations for the global genepool conservation strategy for yam are:

1. Conduct field work in the PA predicted to have suitable habitat for priority CWR but for which occurrence data were not found (Table 4S3).
2. Verify the suitability and accessibility of the recommended genetic reserves, including the soil fertility, topography, location of the sites, population size, threats, landowner, and local policies. Establish four new genetic reserves within PA in the four countries, (Sangha Trinational, Central Africa Republic; Socotra Archipelago, Yemen; Namtok Ched Sao Noi, Thailand; and Blue Fig Creek, Australia), to actively conserve the priority CWR. However, if the suggested sites are not suitable, their range could be adjusted for the active conservation of the yam priority taxa (Song *et al.*, 2020). Improve the population management quality of the four reserves in PA for optimal and active safeguarding of the priority taxa. Also, establish genetic reserve outside existing PA for the nine sites in seven countries (Ethiopia, Nigeria, Democratic Republic of Congo, Magadascar, India, Thailand, and Malaysia), for active *in situ* conservation of the global yam priority CWR.
3. Conduct field survey for the six taxa (*Dioscorea antaly* Jum. & H. Perrier, *Dioscorea calcicola* Prain & Burkill, *D. inopinata*, *D. nummularia* Lam., *D. pynaertii* and *D. sagittifolia*) absent in the network of PA and 10 taxa with < 5 populations in PA (*D. arachidna* Prain & Burkill, *D. brevipetiolata* Prain & Burkill, *D. cirrhosa* Lour, *D. decipiens* Hook. f., *D. hamiltonii* Hook. f., *D. hispida* Dennst., *D. mangenotiana*, *D. oryzetorum* Prain & Burkill, *D. togoensis* R. Knuth and *D. wallichii* Hook. f.) to ensure their *in situ* and *ex situ* conservation.
4. Prioritize the germplasm collection of the five taxa not represented *ex situ* (*D. cirrhosa, D. inopinata, D. lanata, D. pynaertii* and *D. transversa*), 17 taxa underrepresented in genebanks (*D. abyssinica*, *D. antaly, D. arachidna*, *D. baya*, *D. brevipetiolata, D. burkilliana, D. cirrhosa, D. decipiens, D. hamiltonii, D. mangenotiana*, *D. nummularia, D. oryzetorum, D. sagittifolia, D. schimperiana, D. smilacifolia, D. togoensis* and *D. wallichii*) to enhance their effective ex situ representativeness.

5. Identify and prioritize taxa in ELC zones with low frequencies (Tables 4S8 and 4S10) through ELC map tool analysis to ensure that all ELC categories are conserved both *in situ* and *ex situ* (Parra - Quijano *et al.*, 2021).
6. Periodically, review and update the results of this study and the recommendations, especially if there are new goals in the conservation priorities, more occurrence data, recent species distribution modelling techniques and advanced ecogeographic analysis tools.

4.6 CONCLUSION

The bases for a global genepool conservation strategy for yam was developed in this study. The six taxa absent in the existing network of PA and the 10 taxa with < 5 populations were prioritized for urgent *in situ* and *ex situ* conservation. Similarly, the four priority CWR with less than ten occurrence data, the five taxa not represented *ex situ*, and 17 taxa under-represented in genebanks should be prioritized for germplasm collection and preservation. Establishment of the 13 proposed reserve sites will deepen the global conservation effort and priorities for the 27 yam CWR. Also, filling the identified gaps in the conservation of the yam taxa, and implementing the proposed recommendations will facilitate the utilization of the CWR in the modification of their related crops to ensure food security and climate change adaptation. This study will help to guide and consolidate the conservation efforts of the yam genepool *ex situ* collection and for active *in situ* conservation of the crop genepool. The priority CWR can be used as important genetic sources in the improvement of their related crop species.

CHAPTER 5

IMPACT OF CLIMATE CHANGE ON WEST AFRICAN CROP WILD RELATIVES

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5.1 ABSTRACT

The active conservation of crop wild relatives (CWR) is required for crop improvement to ensure global food security for the burgeoning human population in the face of climate change. The impact of climate change on CWR has been widely studied using species distribution modelling. This study analysed the impact of climate change on 63 priority West African CWR using two climate change scenarios: socioeconomic pathway (SSP) 245 and 585 and two timepoints (2050 and 2070). The impact of climate change on West African CWR varied among the taxa, between the scenarios and the timelines. Seven CWR related to four crops were negatively affected by climate change. *Vigna filicaulis* Hepper, a wild relative of cowpea was negatively affected by climate change across all the scenarios and periods. There was an overlap between the predicted distribution of the future climate conditions based on scenarios and periods with loss in taxon-rich areas in the current climate. Predicted current taxa hotspots were found in the south of Ghana, south of Togo, south of Benin, and southwest Nigeria, while the predicted future taxa hotspots were found in Senegal, Gambia, north of Guinea, south and west of Mali, south of Burkina Faso, northwest of Ghana, north of the Benin Republic, northwest, and northeast Nigeria. The knowledge of the impact of climate change on CWR distribution is relevant when planning for conservation to prevent their extinction and ensure their availability for sustainable utilization. Additionally, relevant recommendations have been proposed and included in this study

Keywords: climate change, crop wild relatives, species distribution, socioeconomic pathway, West Africa, conservation

5.2 INTRODUCTION

Climate change is a long-term shift in the average weather pattern across the earth (United Nations, 2023). NOAA National Centers for Environmental Information (2024) reported that the average earth's temperature has increased by 0.06^{0}C per decade and a total of 2^{0}C in the last century, with the highest temperatures recorded in the last decade. Climate change has steadily increased the earth's surface temperature and unpredictable precipitation patterns, leading to abiotic stress and a substantive negative impact on the ecosystem and human community (Raza *et al.*, 2019). The primary driver of contemporary climate change is the release of greenhouse gases into the atmosphere, which trap heat in the atmosphere, leading to a rise in the earth's average temperature. The rising air temperature and the erratic rainfall pattern increase the frequency of drought, flood, desertification, natural disasters, and destruction of properties (Gobiet *et al.*, 2014). The severity of climate change in the next few decades will be determined mainly by the total amount of greenhouse gases released into the atmosphere (O'Neill *et al.*, 2014). If there is no significant reduction in greenhouse emissions, the rise in global annual temperature may exceed 5^{0}C by the end of the century (World Bank, 2023). As postulated by economic models, in the absence of effective intervention, the annual impact of climate change may be up to 5% of the world's Gross Domestic Product (IPCC, 2021). Agrodiversity loss is increasing due largely to climate change that is persistently ravaging suitable arable lands and crop productivity (Habibullah *et al.*, 2022; Chen *et al.*, 2023). Due to the increasing negative effect of climate change, the United Nations, through Goal 13 of the Sustainable Development Goals calls for urgent action to mitigate climate change and its impacts (United Nations, 2020). Also, biodiversity conservation, sustainable utilization of genetic resources, and orthodox ecological practices could reduce subsequent biodiversity loss and increase food provision in the event of climate change (Habibullah *et al.*, 2022; Hoveka *et al.*, 2022).

The effect of climate change on global food security has been a major challenge in recent years (Porter *et al.*, 2014). Global mean surface air temperature is predicted to rise from 0.4% to 2.6%, while periods of excessive temperature rise may frequently occur in the future, such as heat waves adversely affecting food production (IPCC, 2014). Significantly, this disrupts the flowering of plants, leading to the unavailability of seeds and exposing plants to diseases (Baldwin *et al.*, 2019). Climate change will also affect precipitation patterns and water availability. While there are droughts and heat waves in some parts of the world, other areas will experience heavy rainfall and flooding (Bellard *et al.*, 2014). Climate change is a major cause of hunger and malnutrition, disrupting agricultural activities and means of livelihood (Bloom and Plant, 2021; Mirzabaev *et al.*, 2023). Loss of crops may result from rising sea levels (Chen *et al.*, 2023). Additionally, climate changes are the major causes of biotic and abiotic stresses which affect agriculture adversely (Groenen, 2018; Sánchez-Bermúdez *et al.*, 2022). Heat stress from heat waves may change the distribution pattern of some pests, potentially leading to a wider distribution area (Wheeler and Von Braun, 2013; Bailey *et al.*, 2015). Climate change is projected to worsen the adverse effect of drought and increase in temperature and salinity (Field and Barros, 2014; Banerjee *et al.*, 2018). Globally, a crop yield decline of 3% to 10% has been predicted per degree rise in temperature (Challinor *et al.*, 2014). Significant food production uncertainty has been attributed to climate change impact, resulting from drought and a shortage of water supply for agricultural activity (Kang *et al.*, 2009; Mbow *et al.*, 2017; Bloom and Plant, 2021). Despite the increased global food production to feed the world, 10% of the world's population is undernourished, while the number of people living with insufficient food provision increased by 40% in 2022 (Chen *et al.*, 2023). With 33% of the world suffering from micronutrient deficiency, and the increasing loss of biodiversity, the availability of healthy and sustainable food systems may be disrupted soon (IPCC, 2021). Climate change will significantly lead to a rise in food prices in the future (Arora, 2019). About 690 million people or 8.9% of the world population live in hunger, while an estimated 750 million, or one in ten people are affected by extreme levels of food insecurity (FAO, 2020). Reducing the impact of climate change on agricultural productivity and feeding the burgeoning population, is a major global challenge (Brás *et al.*, 2021).

Crop wild relatives (CWR) are wild species closely related to crops that have undergone natural evolution with no anthropogenic interference and possess resilient traits that can help crops to adapt to climate change (Maxted *et al.*, 2006). They are hardy and vigorous species that grow under less hospitable environment, receiving no input such as fertilizer, irrigation, herbicides, and pesticides (Levis *et al.*, 2018). They compete with weeds, thrive under pest and diseases and are resilient to harsh and heterogenous environmental situations (Luna-Ruiz *et al.*, 2018). CWR are required in increasing the genetic base of crops and adapting crops to marginal environment (Maxted *et al.*, 2013; Flores-Hernández *et al.*, 2018) reported that about 16 to 22% of potato, cowpea, and peanut CWR are expected to go into extinction by 2055, while the habitat of maize is predicted to become severely fragmented, due to climate change. Substantial investment in crop resilience through improvement with CWR is needed to increase crop yield and meet global food demand (Dawson *et al.*, 2016; Nabhan *et al.*, 2020). Adapting crops to marginal environmental conditions as well as maintaining the high yielding quality of crops is necessary in meeting the human nutritional demand (Warschefsky *et al.*, 2014). Amongst others, CWR with genes for drought tolerance has been identified in wild relatives of tomato (Vincent *et al.*, 2013), barley (Park *et al.*, 2015), common bean (Blair *et al.*, 2016) and rice (Atwell *et al.*, 2014), while genes for salt tolerance have been found in several CWR such as wild rice species (*Oryza coartata* Roxb.) and wild sunflower (*Hellanthus paradoxus* Heiser) (Vincent *et al.*, 2013).

West Africa has contributed little to the global greenhouse emission; however, it is one of the most affected by climate change (Adzawla *et al.*, 2019). In West Africa, rainfall is projected to decrease with delayed rainfall and average surface temperature higher than the global average (IPCC, 2021). Climate change has led to desertification and biodiversity loss in West Africa, with deforestation and land use activities playing certain roles (IPCC, 2014). Increase in temperature, shift in precipitation pattern, undulating wind speed affecting water bodies and coastal agricultural activities has been observed (Di Nuzzo *et al.*, 2021). Climate change is expected to shorten cropping season and increase water stress (Chen *et al.*, 2023). Mali and Burkina Faso in West Africa are the hottest countries in the world with a yearly average temperature of 28.83^{0}C and 28.71^{0}C, respectively (World Population Review, 2023). In West Africa, agricultural productivity has reduced by over 30% in the last six decades, more than any other region (IPCC, 2021) and increased temperature and reduced rainfall have decreased economic growth in the region (Baarsch *et al.*, 2020; Di Nuzzo *et al.*, 2021). This has further affected irrigation agriculture and livestock farming (IPCC, 2022). At an increase with 1.5^{0}C average surface temperature, maize yield is projected to decrease by 9% in West Africa, while sorghum will be severely affected at the same temperature (IPCC, 2018). There is observed decline in crop productivity due to climate change in West Africa (Tarchiani *et al.*, 2017), with 27 million people going hungry (Chen *et al.*, 2023). Maize and wheat yield decreased by 5.8% and 2.3% respectively across Africa from 1974 to 2008, due to climate change (IPCC, 2021). Flooding, drought, heat waves, rising sea level and frequent and intense storms have therefore affected the livelihood of the region. About 32 million West African could be displaced due to the climate change crisis (World Economic Forum, 2021) and a high risk of biodiversity loss and species extinction (United Nations, 2023). The aim of this work is: (i) to identify the range of distribution change of priority CWR due to climate change (ii) to determine the magnitude of range shift by the priority taxa resulting from climate change, and (iii) to suggest how the affected taxa can be conserved to prevent their extinction and to ensure their availability for sustainable utilization.

5.3 METHODS

5.3.1 CWR Occurrence Data

Occurrence data for the 102 West African priority CWR (Nduche *et al.*, 2021) were obtained from international sources such as Global Biodiversity Information Facility (GBIF.org, 2020), Genesys Global Portal on Plant Genetic Resources (Genesys, 2020), RainBio (Dauby *et al.*, 2016), and Royal Botanical Gardens, Kew (www.kew.org/kew-gardens). The delineation and botanical classification of the CWR were verified in Germplasm Resources Information Network (GRIN) taxonomy (USDA, 2021) and Plant List http://www.theplantlist.org. Distributional data lacking degree coordinates were converted to decimal degree using Canadensys (https://data.canadensys.net/tools/coordinates). Duplicate records, i.e., records with the same distributional but from different sources or reported twice from the same source (Magos Brehm *et al.*, 2017a) were deleted, while those that were erroneously located in neighbouring countries were reviewed, and corrected whenever possible, prior to the analysis. The accuracy of species distribution models, rely strictly on the accuracy of the coordinates of the occurrence data. To optimize the precision of the records, collection sites coordinate, with unique present points were used in the analysis. The occurrence records were verified using the 'TesTable tool' of CAPFIOGEN3 to ensure they meet the requirements for other CAPFITOGEN3 tool analyses. Similarly, the quality of the coordinates and collection sites of the data were corrected, using the GEOQUAL tool of CAPFITOGEN3 (Parra - Quijano *et al.*, 2021; Magos Brehm *et al.*, 2022; Nduche *et al.*, 2023).

5.3.2 Environmental Variables for Current and Future Climate Analysis

The current climate raw data were directly sourced from WorldClim 1.4 climate surface (www.worldclim.org), because of their high spatial resolution and global extent (Hijmans *et al.*, 2005).

Globally, it uses data from over 47, 000 weather stations to generate interpolations and uses the thin-plate splines algorithm (Hutchinson, 1995; Hijmans *et al.*, 2005). The variables for the current climate condition were created by averaging climate information from 1950 – 2000, for monthly precipitation, and minimum and maximum temperatures. The environmental variables were obtained for each presence point of the target CWR. A cumulative consecutive test was used to select unrelated variables with variation inflation factor (VIF), at a threshold of < 5. Further analysis was carried out for taxa that did not exceed the threshold, using the Random Forest Algorithm, at Pearson's correlation of < 0.66 (Cutler *et al.*, 2007), and processed in the SelecVar tool of CAPFITOGEN3 (Parra - Quijano *et al.*, 2021)

The Global Circulation Models (GCM) developed by the Coupled Model Intercomparison Project Phase 6 (CMIP6) and adopted in the IPCC – Sixth Assessment Report (IPCC6) (IPCC, 2021) were used in the analysis (Table 5.1). Based on the Sixth International Panel on Climate Change (IPCC) report (IPCC, 2021), the decimal degrees, the geographic coordinate system of WGS84, and the ASCII format of future bioclimatic variables for the shared socioeconomic pathways (SSP) SSP 245 and SSP 585 green gases (GHG) emission scenarios for a midterm future period of the year 2050 and long-term future period of 2070 were downscaled from CCAFS (www.ccafs-climate.org). The models are reported to give different response information on the impact of climate change to the world's terrestrial and atmospheric hemispheres. The SSP 245 is an updated version of RCP 4.5, representing the moderate medium pathway of future greenhouse gas emissions, with an additional anthropogenic forcing of 4.5 W/m^2 by the year 2100. Conversely, SSP 585 represents the upper boundary of the range of scenarios with an additional anthropogenic radioactive forcing of 8.5 W/m^2 by the year 2100; it is an update of CMIP5 RCP8.5 with socioeconomic scenario (Riahi *et al.*, 2017). Soil and geophysical components are reported not to change with climate variability evidentially (Pearson and Dawson, 2005; Phillips *et al.*, 2017).

Table 5.1: Models used in the predicted distribution.

S/N	Climate model	Model code	Developer
1	The Canadian Earth System model version 5	canasm5	The Canadian Centre for Climate Modelling and Analysis, Canada
2	Goddard Institute for Space Studies, mode E2.1 -G	giss_e2_1g	National Aeronautics and Space Administration, USA
3	Institut Pierre – Simon Laplace (IPSL) – CM6A - LR	Ipsl_cm6a_ir	Institut Pierre – Simon Laplace (IPSL), Paris, France

4	The Sixth version of the model for Interdisciplinary Research on Climate (MIROC)	miroc	Japan Agency for Marine Earth Science and Technology, Japan
5	UK Earth System Modes	Ukesm1_0_11	Natural Environmental Research Council (NERC) and Met Office, UK

5.3.3 Species Distribution Modeling

Species distribution models are numerical tools that correlate climate data with occurrence records, to determine a taxa-predicted range (Barlow *et al.*, 2021). Predicted taxon hotspots were determined based on the distribution models of those taxa with more than 10 distributional records and ecogeographical layers (Hijmans and Spooner, 2001 ; Phillips *et al.*, 2006 ; Di Nuzzo *et al.*, 2021). Current and future climate species distribution models were generated using the Maximum Entropy (MaxEnt) algorithm (Phillips *et al.*, 2006). It is one of the most effective and widely used techniques for ecological spatial modelling (Elith *et al.*, 2006; Elith and Graham, 2009). It operates by contrasting the range of scenarios linked to the taxa occurrence with the range of scenarios across the spatial landscape (Elith *et al.*, 2011; Fielder *et al.*, 2015; Phillips *et al.*, 2017). To test and train the models, a cross-validated method was used (Elith *et al.*, 2010), at fivefold replicates for taxa with 10 to 50 distributional data points and 10-fold replicates for those with over 50 location data points. The maximum training sensitivity plus specificity threshold was applied for each taxon (Liu *et al.*, 2005). The models were then validated for their robustness according to three criteria: (a) average area under the test data receiver operating characteristics (ROC) curve (ATAUC) above 0.7 (b) standard deviation of the ATAUC (STAUC) below 0.15, and (c) the proportion of predicted distribution area with STAUC over 0.15 (ASD15) below 10%. For a model to be valid, all the three conditions must be met (Ramírez-Villegas *et al.*, 2010; Castañeda-Álvarez *et al.*, 2016). Models that pass this test for current and future conditions were processed, visualized, and analysed on DIVA-GIS 7.5 (Hijmans and Spooner, 2001) and QGIS (QGIS-Development Team, 2021).

5.3.4 Climate Change Impact Analysis

To determine the impact of climate change on priority CWR, the grids of the current and future distribution maps were overlaid on DIVA-GIS (Hijmans *et al.*, 2012), which resulted in four different situations: (i) High-impact areas (range contraction): areas where species are currently predicted to occur but that will not be suitable in the future (ii) Areas outside of the realized niche: which are neither suitable under current nor future climate conditions (iii) Low impact areas (occupied); where the species are likely to occur in both current and future climates; and (iv) New suitable areas (range expansion): where the species could potentially occur in the future but are not suitable in the current climate (Scheldeman and van Zonneveld, 2010; Puchałka *et al.*, 2023). To solve the problem of not being able to differentiate (ii) and (iii) on DIVA- GIS, the threshold values of the consensus grid was reclassed. The number of pixels for the files were determined by opening the attribute table of each file on ArcMap (ESRI, 2015) and species range change was calculated using the following formula:

$$SRC \;=\; (c-a)/d,$$

where SRC= Species range change, a = number of pixels for high impact areas, c = number of pixels for potential new areas, d = current suitable areas.

The number of pixels representing each scenario and timelines were summarized to determine the magnitude of range shift as range contraction, occupation, and expansion. The high impact area represents range contraction, the low impact area constitutes the occupied, while the new suitable areas form the range expansion (Puchałka *et al.*, 2023)

5.4 RESULTS

5.4.1 CWR occurrence data overview

The number of occurrence records for the priority taxa ranged from three to 3594. *Oryza glaberrima* Steud has the highest number of occurrence records, while 38 taxa had more than 50 occurrence data points (Table 5S1). Benin and Nigeria had the highest number of occurrence records 6428 (31.9%) and 2358 (11.7%), respectively (Nduche *et al.*, 2023). Of the 102 priority West African CWR, 63 had valid distribution models of current climate conditions. The SDM of 55 priority CWR passed the validation criteria, however, for the other 8 taxa a CA50 buffer area was created around each presence point and 26 had no occurrence data (Table 5S1 and 5S2). The 63 taxa (related to 15 crops) were used to determine the impact of climate change on their distribution

5.4.2 Predicted Species Range change

The predicted impact of climate change varied among the priority taxa, between the scenarios and the years. SSP 585 scenario for the year 2070 is predicted to most negatively impact CWR because more taxa were affected on this year point and scenario more than any year's scenario, with five taxa affected. However, not all taxa were negatively affected by the adverse environmental conditions (Table 5S3). One taxon, *Vigna filicaulis* Hepper, a wild relative of cowpea, is predicted to be very negatively affected by climate change (negatively affected in the two scenarios and two years period). It maintained a negative range change between -0.73 and -0.75 pixels across the scenarios and years (Table 5S3). Seven species (11.11%) of the taxa are predicted to be negatively affected by climate change, while 58 (92.06%) of the taxa were positively affected by climate change (Table 5S3). The crop genepools negatively affected by climate change are cowpea (three taxa), rice (two), yam and sorghum, one each (Fig 5.1 and Table 5S3). By 2050, the species range change varied from -5.86 in *V. unguiculata* subsp. *letouzeyi* to 63.4 in *Dioscorea. alata*, based on SSP 245 scenario. On the other hand, by 2070, the species distribution change, ranged from -0.74 in *Vigna filicaulis* based on SSP 585, to 72. 99 in *Dioscorea. alata* (SSP 245) (Table 5S2). Conversely, *Cola angustifolia*, *Dioscorea alata* and *Vigna oblongifolia* are predicted to be positively affected by climate change across the two scenarios and years (Table 5S2).

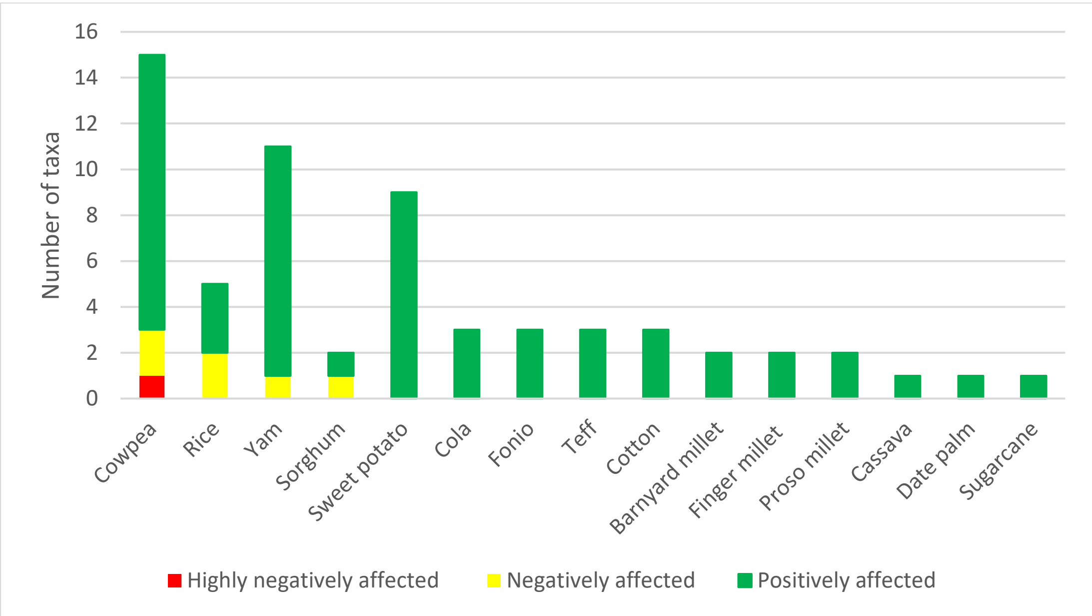

Fig 5.1. Number of taxa in each crop genepool to be affected by climate change

5.4.3 Predicted taxon distribuion richness

The hotspots of the predicted taxon richness for the current climate were found in south of Ghana, south of Togo, south of Benin and south west Nigeria (Fig. 5.2). The predicted distribution for the two scenarios and year periods overlapped. By 2050, predicted distribuion richness, based on SSP 245 scenario, showed CWR taxon hotspots to be in Senegal, north of Guinea, southern west of Mali, north of Benin Republic, north west and north east Nigeria (Fig. 5.3). By 2070, the hotspots were located in Senegal, Gambia, north of Guinea, south and west of Mali, south of Burkina Faso, north west of Ghana, north of Benin, and north west Nigeria for 245 scenario (Fig. 5.4). By 2050, under the SSP 585 scenario, hotspots are located in Senegal, north of Benin, and north west Nigeria (Fig. 5.5). Under the SSP 585 scenario, by 2070 period, the hotspots are located in north of Guinea and north west Nigeria (Fig. 5.6). There was a slight loss of taxon richness in south of Ghana, south of Togo, south of Benin and south west Nigeria for all the scenarios and years compared to the predicted distribution under current climate conditions (Fig. 5.2). Taxon richness increased across the region from a predicted diversity richness of maximum of 50 taxa under the present climate condition to 62 under SSP 245 (2050 and 2070) and SSP 585, for the year 2050 (Fig. 5.2 to Fig. 5.5). However, the predicted richness for SSP 585, year 2070 reduced to maximum of 40 in taxon rich areas (Fig. 5.6). The differences between the predicted distribution of the CWR under current and future climate conditions show slight reduction in taxon richness in some areas but an increase in others (Fig. 5.7 to Fig. 5.10).

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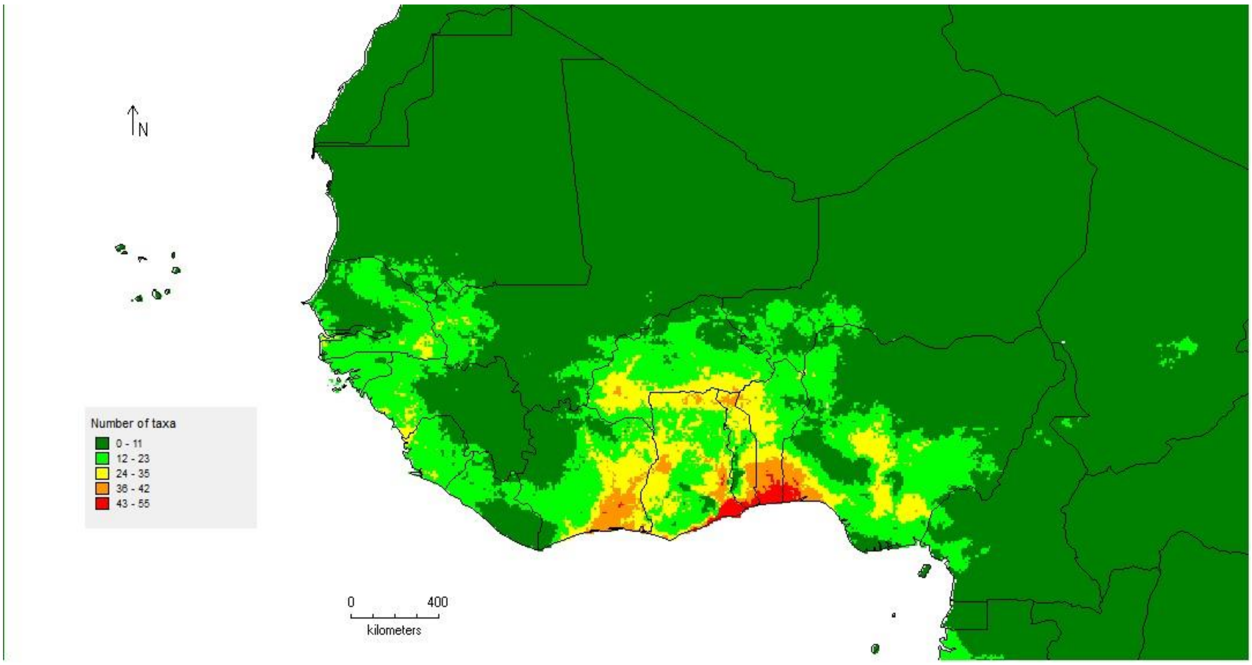

Fig 5.2: Predicted distribution of 63 West African priority CWR for which species distribution models were considered valid, based on current climatic conditions. Grid cell size is 0.4 degrees.

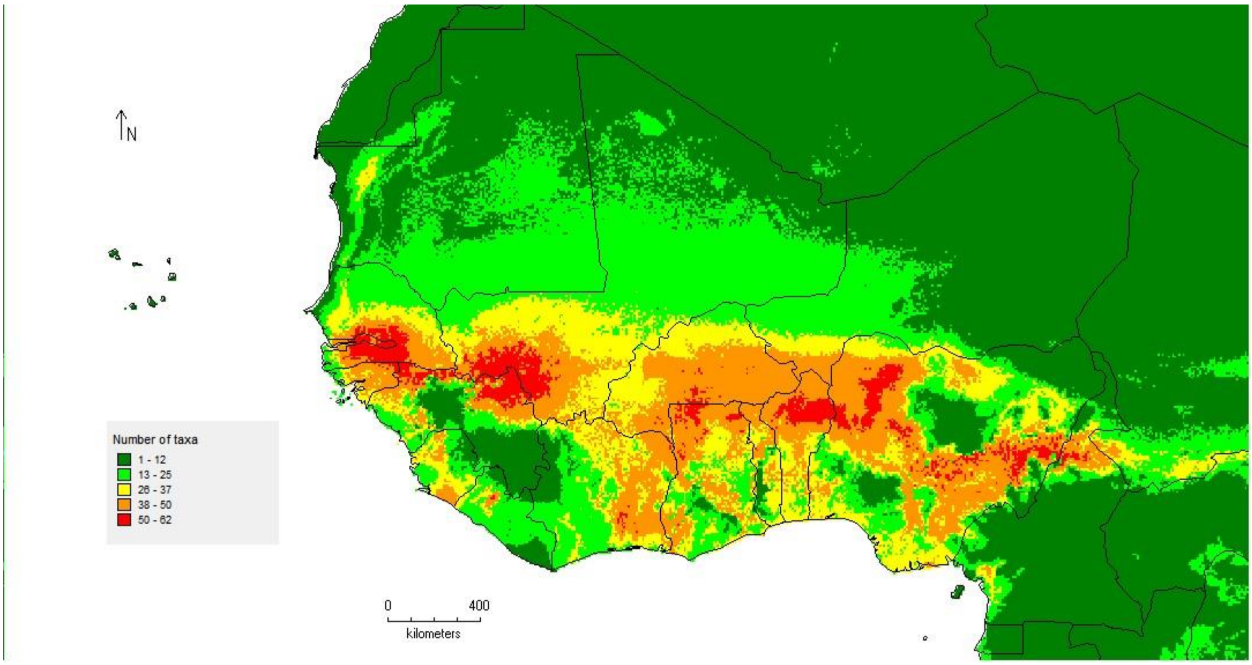

Fig. 5.3: Species richness projected to 2050 climate condition under SSP 245 for the 63 West African CWR for which species distributon models were considered valid. Grid cell size is 0.4 degrees.

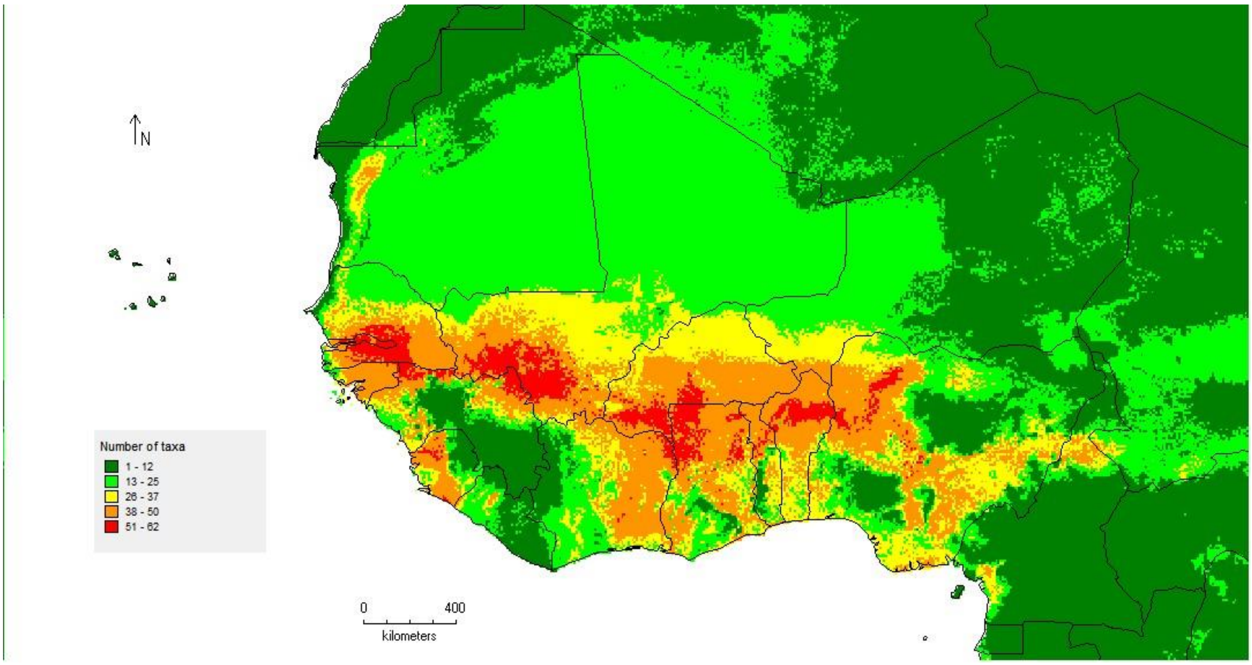

Fig. 5.4: Species richness projected to 2070 climate condition under SSP 245 for the 63 West African CWR for which species distribution models were considered valid. Grid cell size is 0.4 degrees.

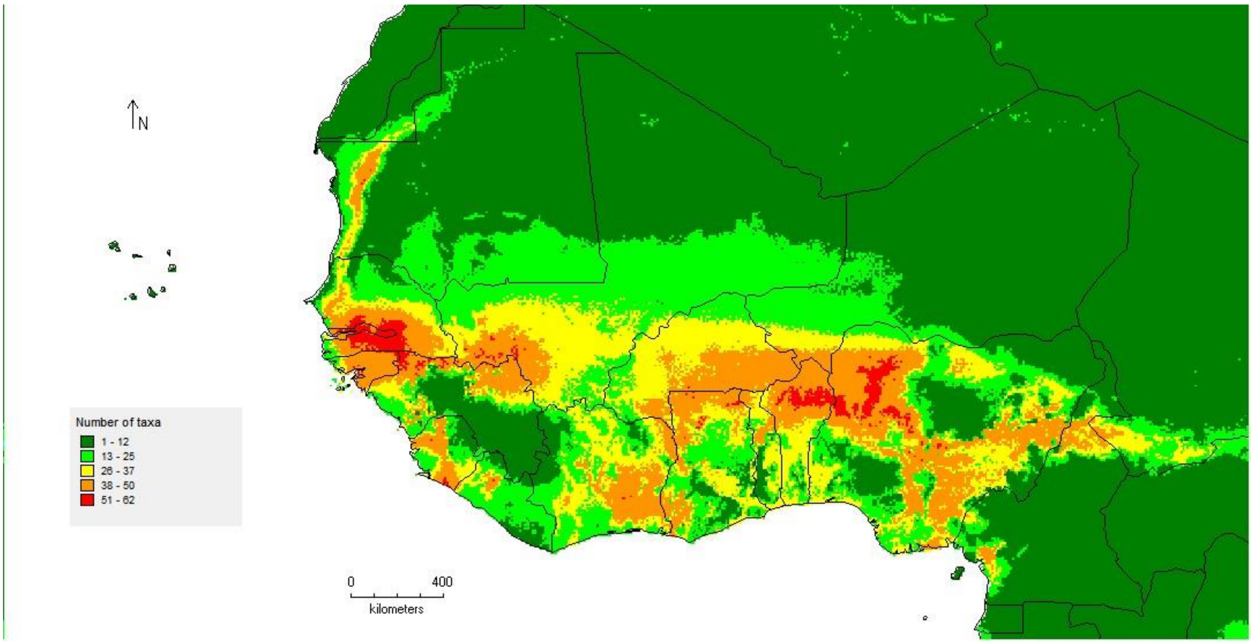

Fig. 5.5: Species richness projected to 2050 climate condition under SSP 585 for the 63 West African CWR for which species distribution models were considered valid. Grid cell size is 0.4 degrees.

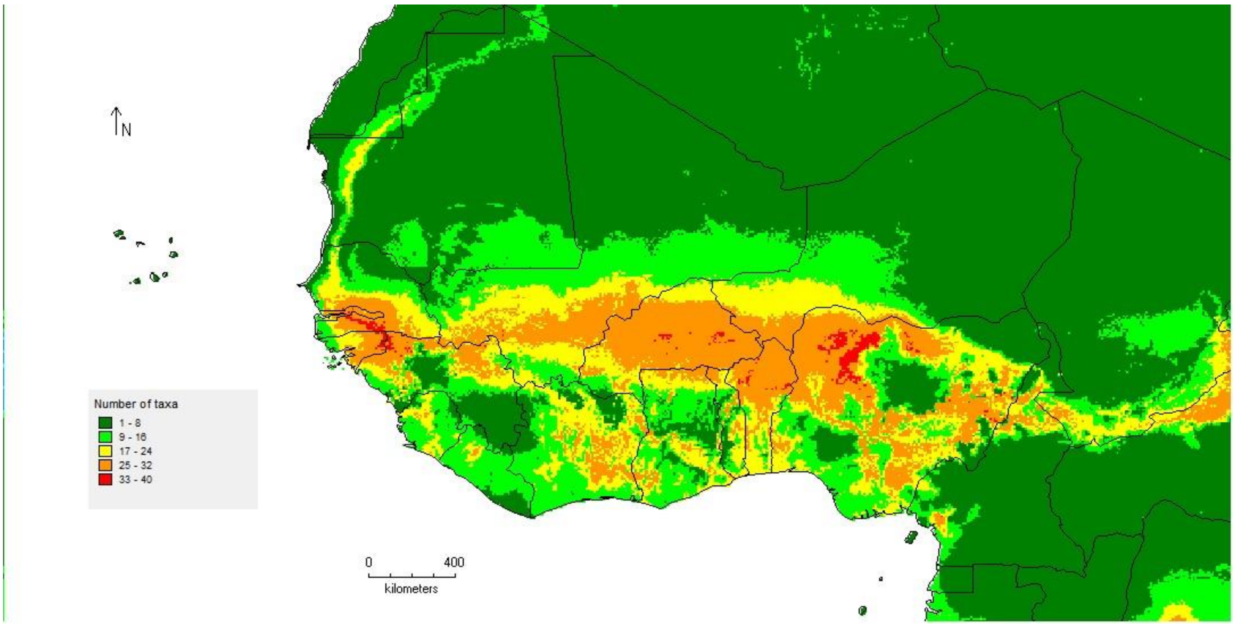

Fig. 5.6: Species richness projected to 2070 climate condition under SSP 585 for the 63 West African CWR for which species distributon models were considered valid. Grid cell size is 0.4 degrees.

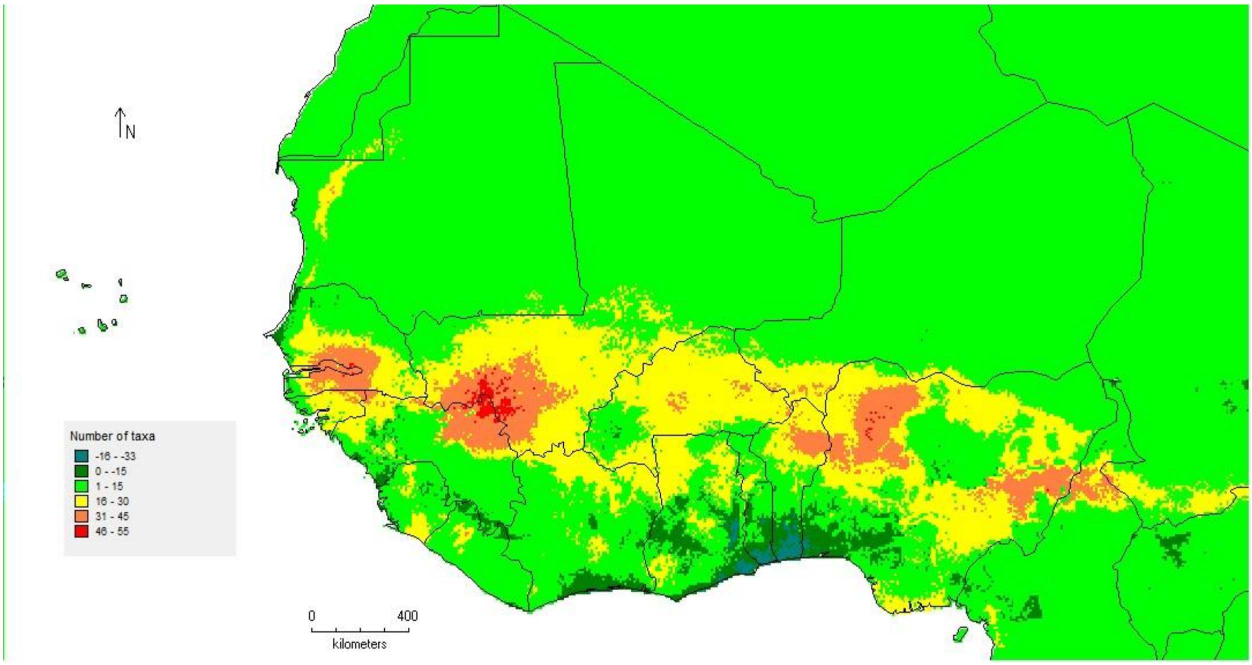

Fig. 5.7: Predicted taxon richness comparing the current and future under SSP 245 scenario, based on 2050 period. Grid cell size is 0.4 degrees.

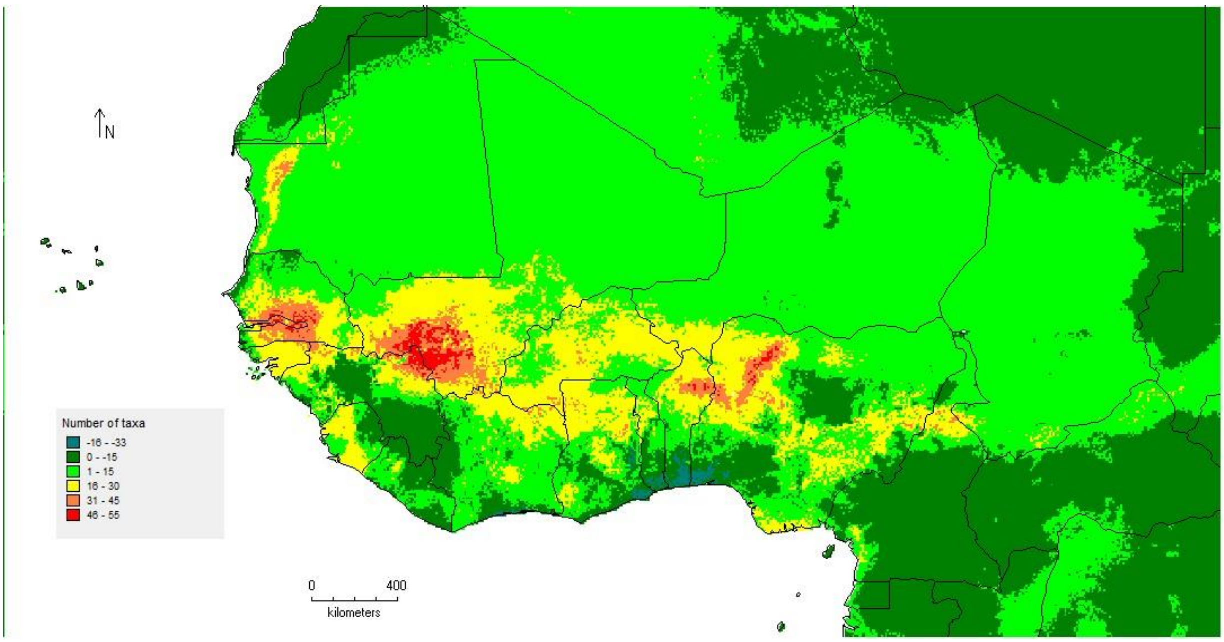

Fig. 5.8: Predicted taxon richness comparing the current and future under SSP 245 scenario, based on 2070 period. Grid cell size is 0.4 degrees.

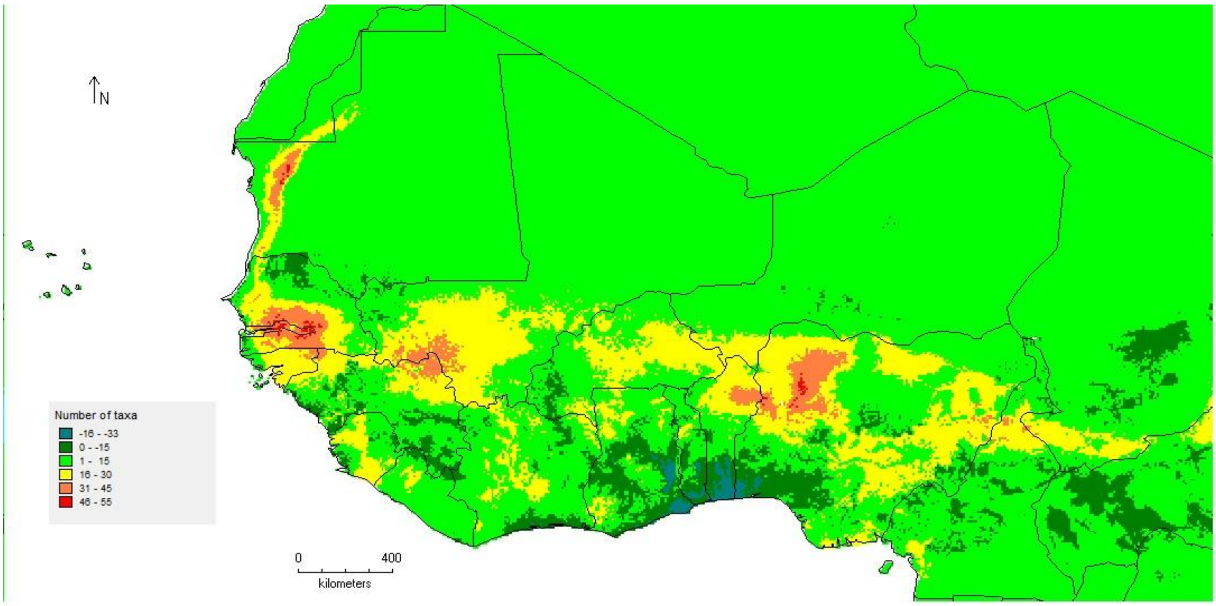

Fig 5.9: Predicted taxon richness comparing the current and future under SSP 585 scenario, based on 2050 period. Grid cell size is 0.4 degrees.

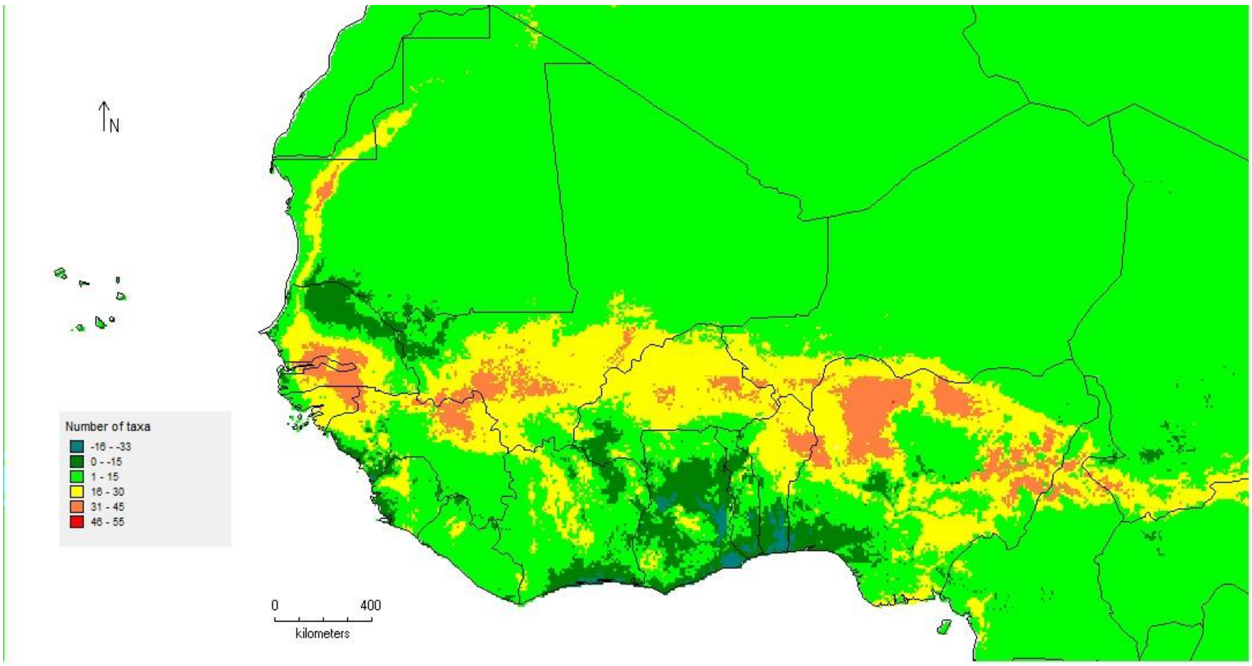

Fig. 5.10: Predicted taxon richness comparing the current and future under SSP 585 scenario, based on 2070 period. Grid cell size is 0.4 degrees.

5.4.4 Magnitude of predicted range shift

The areas classified as range contraction, occupied and expansion varied among the CWR and between the scenarios and timelines. The largest range contraction is expected for *V. filacaulis* (52.06%), under the SSP 245 scenario, for 2070, SSP 585 for 2050 and 2070, while the smallest range contraction is expected for *V. oblongifolia* (0.01%), under the scenario SSP 585, for 2050 (Table 5S3). Conversely, the largest range expansion is expected for *Oryza barthi* (63.31%), under SSP 245 scenario, for 2050, while the smallest range expansion is predicted for *V. filacaulis* (0.18%), under SSP 245 scenario for 2070. For the predicted occupied magnitude of range shift, the largest areas expected to remain occupied is for *Sorghum purpureosericeum* (54.37%), under SSP 585 scenario for 2070 (Table 5S3). At the genepool level, the largest and least contracted distribution areas are predicted for cowpea (114.7%) and cassava (0.39%), respectively, under SSP 245 for 2070 (Fig. 5.11). On the contrary, the largest expected expansion area is for rice (615.42%), under 245 scenario for 2050, with the least expansion area, predicted for date palm (10.23%), under SSP 585 scenario, for 2050. (Fig. 5.12). The occupied distribution area of rice is expected to decrease under the SSP 585 scenarios for both 2050 and 2070 (Table 5S4).

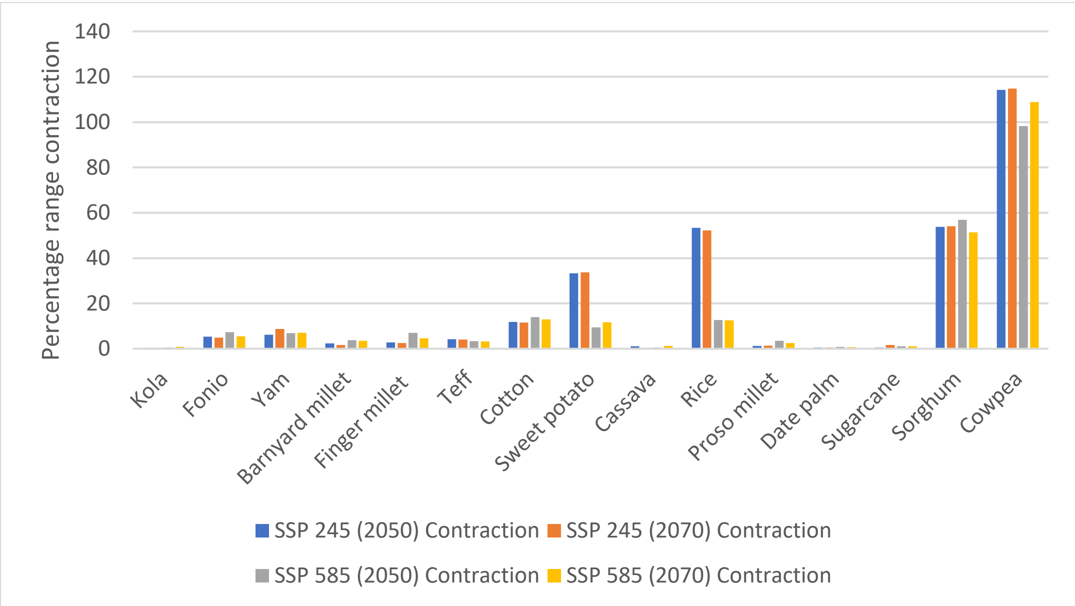

Fig. 5.11 Percentage range contraction of the crop genepools under the SSP 245 and SSP 585 scenarios based of 2050 and 2070 timepoints.

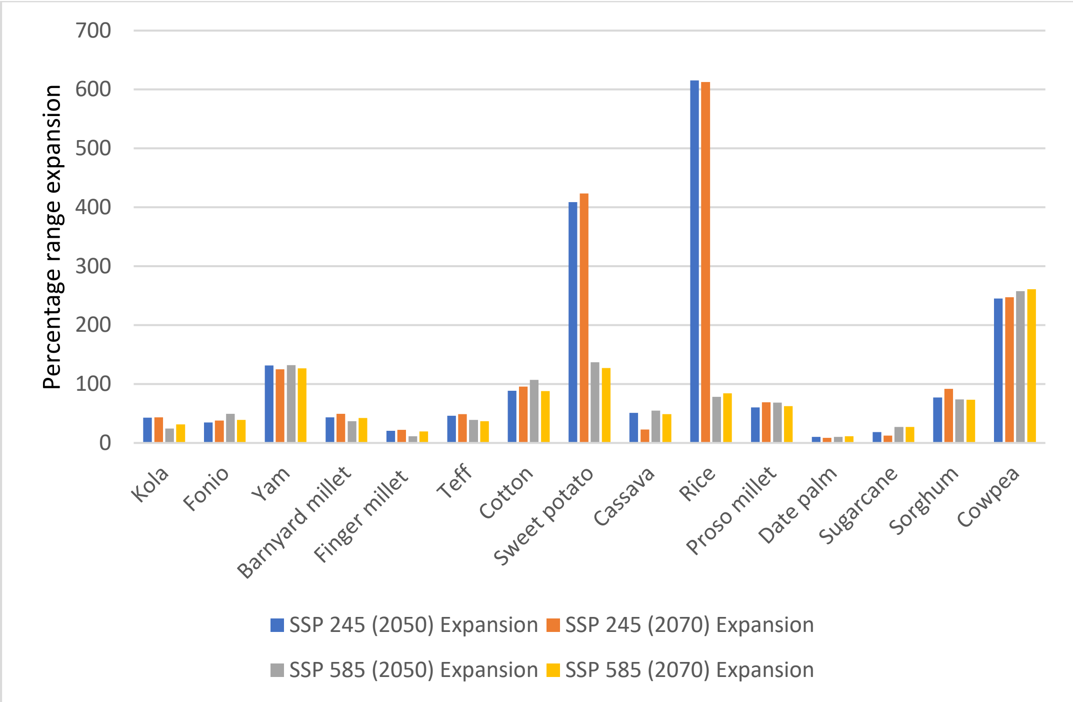

Fig. 5.12 Percentage range expansion of the crop genepools under the SSP 245 and SSP 585 scenarios based of 2050 and 2070 timepoints.

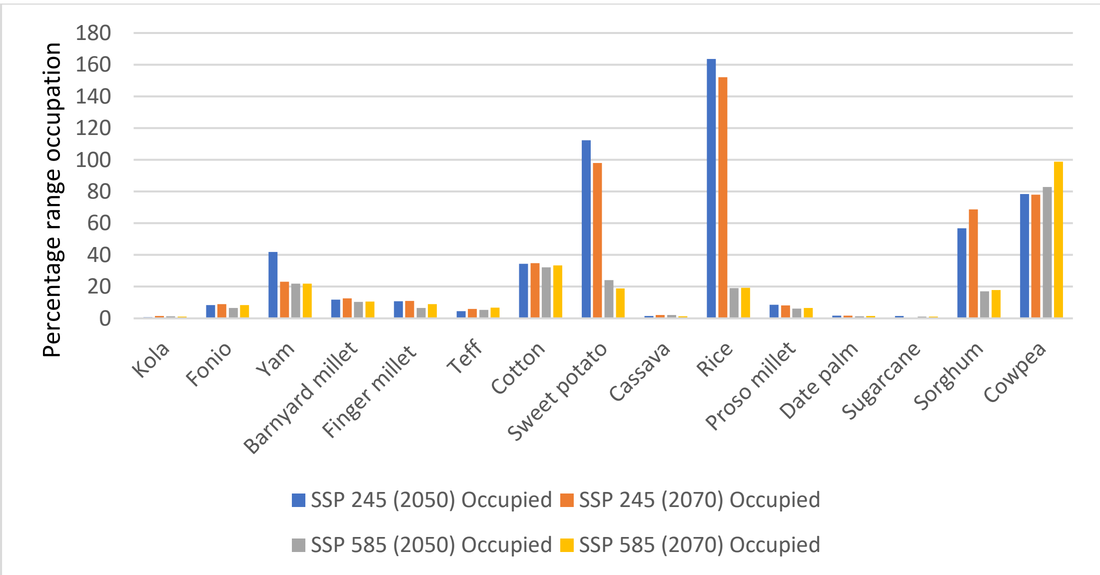

Fig 5.13 Percentage range occupation of the crop genepools under the SSP 245 and SSP 585 scenarios based of 2050 and 2070 timepoints.

5.5 DISCUSSION

The invaluable contribution of CWR in food security and climate change mitigation, implies that it requires urgent and active conservation to safeguard it from adverse enviromental conditions, prevent its extinction and ensure their future availability. West Africa is a region prone to negative climate change impact, with its effect already higher than the global average (Tarif, 2023), specifically, on the region's environment, economic security and food provision and it is likely to get even worse. In this study, we presented the outcome of the analysis of the predicted impact of climate change on 63 priority West African CWR. Of the 63 priority taxa, 59 are regional endemic, while four are nationally endemic (Nduche *et al.*, 2021). This study provides one of the first current and future predictions of climate change on important wild relatives in West Africa.

The impact of climate change on crops and their wild relatives have been reported by several autors (Cobben *et al.*, 2013; Phillips *et al.*, 2017; Ray, 2019; Ratnayake *et al.*, 2021; Magos Brehm *et al.*, 2022; Rahman *et al.*, 2023). Climate change can result in reduction in agrobiodiversity, both at species and genetic diversity levels and increase in vulnerability to pest and diseases. The distribution range and suitable habitats of crops and their wild relatives can be reduced or fragmented due to unmitigated climate effects. The outcome of this study shows that the habitat range of seven CWR related to four crops are predicted to be negatively affected by climate change, with *V. filicaulis* affected across the two scenaros and periods (Table 5S2). Jarvis *et al.* (2008) reported that CWR from the *Vigna* genus, are potential taxa for domestication and commercialization. Goettsch *et al.* (2021) reported that 35% of 224 Mesoamerican CWR are threatened with extinction. In this study, none of the 63 CWR is predicted to become extinct, however, unpredictable adverse climatic condition and complex ecological situations can pose a threat to taxa. Potentially, the CWR that are likely to be at the risk of extinction were not included in the analysis, due to lack of occurrence data, which is a prerequite for the impact evaluation. The lack of occurrence data, is on its own is also an indication that a taxa may require impact assessment. Crop Trust (2016) reported that 23.9% of CWR have less than 10 occurrence records in database. Also, Contreras-Toledo (2019) opined the urgent need for the collection missions of wild relatives of important crops like sweetpotato, sorghum, cassava, and staple food crop like rice and wheat. Amongst the CWR negatively affected in West Africa is *Oryza longistaminata*, used for the improvement of rice for drought tolerance (Hajjar and Hodgkin, 2007), yield improvement (Brar, 2005), and bacterial blight resistance (Jena, 2010). Also, *Sorghum purpureosericeum*, used for the improvement of sorghum for resistance against sorghum shoot fly (Nwanze *et al.*, 1990), is predicted to be negatively affected by climate change and is not conserved *ex situ* (Nduche *et al.*, 2023). The taxa most positively affected by climate change such as *Cola* *angustifolia*, *Dioscorea alata* and *Vigna oblongifolia* can be used to adapt their related crops to climate change. *Dioscorea alata* has confirmed uses in breeding white Guinea yam (*Dioscorea rotundata* Poir) for resistance against anthracnose, improved cooking quality, and reduced tuber oxidation (Lopez-Montes *et al.*, 2012). These CWR are also expected to broaden the genetic base of their related crops and cultivars (Ostrowski *et al.*, 2016) Understanding the correlation between climate change and CWR distribution will contribute to evaluating their level of threat and conservation needs.

The trend in predicted hotspot diversity richness showed that it will move from the south of Ghana, south of Togo, south of Benin, and south west Nigeria in the current climate condition to Senegal, north of Guinea, south west of Mali, north of Benin Republic, north west and north east Nigeria by 2050, based on SSP245 scenario; to Senegal, north of Benin, and north west Nigeria, under the SSP 585 scenario by 2050; to Senegal, Gambia, north of Guinea, south and west of Mali, south of Burkina Faso, north west of Ghana, north of Benin, and north west Nigeria, based on 245 scenario by 2070; and to north of Guinea and north west Nigeria, under the 585 scenario, by 2070. A shift in taxon rich area may be due to fragmentation of the taxa, lack of suitable area, driven by human perturbations and other ecological factors such as competition, dispersal dynamic, and other physiological and morphological features of the taxa (Ratnayake *et al.*, 2021). Mode of dispersal can contribute to the range expansion of certain taxa. For instance, wild relatives of crops such as sorghum reproduce by self-pollination, and can gain range expansion since they don't need another individual for pollination to occur. Similarly, seeds of taxa dispersed by explosion and wind, such as cowpea and cotton, respectively, can overcome natural barriers to new locations (Ruxton and Schaefer, 2012; Cullen and Hay, 2024). There was also a significant latitudinal shift of predicted taxon richness westward from south west Nigeria, south of Benin, south of Togo and Ghana, towards Senegal, Gambia, north of Guinea, south and west of Mali. This is in line with the findings of Fei *et al.* (2017) who reported a latitudinal shift of some tree species from the eastern United States, towards the west. On the other hand, the gain in the predicted future hotspots will add to more suitable areas for the taxa (Bradley, 2016; Ricciardi *et al.*, 2021). However, some plant species are known to shift their habit distribution to other geographical directions (Dolan and Kilgore, 2018). The predicted hotspots show that optimal climatic conditions for target taxa is expected to be favourable in their predicted niche, which may also be beneficial to other taxa. These potential diversity rich areas are likely to be favourable to other wild taxa. Relatively, taxa richness was higher at the south part of the region than the northern part. This is in agreement with the finding of Jarvis *et al.* (2008) who reported that taxa tend to move to more cooler parts of the area.

The magnitude of range shift varied among the taxa, between the scenarios and timepoints. For instance, the contraction and persistence were higher under SSP 245 for sweet potato and rice, while the persistence was also higher for sorghum and yam (Fig. 5.11 to 5.13). The highest occupied range by rice (163.66%), under SSP 245 scenario, by midcentury, and it's subsequent decline by 2027 is consistent with the report by Olszewski *et al.* (2022) that the climatically suitable area for beewolf (*Phylanthus triangulum* Fabricius) will increase by mid century and then decrease by 2070. Similar result was also reported by Puchałka *et al.* (2023) on the range shift of black (*Robinia pseudoacacia* L.) under climate scenarios, by the same timepoints. The decrease in the predicted occupied area of rice under the SSP 585 scenario is consistent with the finding of Akpoti *et al.* (2022), that climate change may cause a plausible loss in the yield of rice, if farmers are not given the right tools to adapt it to climate change. Fei *et al.* (2017) reported that taxon response to climate change varies, and is species specific. Though the potential distributon of some taxa has been predicted into later timepoints, 2060 to 2080 (Thurm *et al.*, 2018), 2081 to 2100 (Ostrowski *et al.*, 2016), there is urgent need to conduct a predictive study of some taxa from the present to the next five decades, as most of the changes predicted are already in existence. Our results showed an increased taxon richness from a maximum taxon number of 55 in taxon rich areas for the predicted current climate to 62 in the predicted future climate condition for SSP 245 scenario, by 2050 and 2070 periods and SSP 585 scenario, by year 2050. This is in congruence with the report by Phillips *et al.* (2017), that the taxon richness for Norwegain CWR increased in the future, under climate change scenarios. Di Nuzzo *et al.* (2021) reported that plant taxa show differences in taxon richness in responds to climate change.

Active conservation can be prioritized for those taxa expected to be negatively impacted by climate change and those with predicted reduced occupied area (Vincent *et al.*, 2019). Range change, taxon richness and magnitude of range shift should form part of the criteria in CWR prioritization. Existing PA in areas predicted to have hotspots, both in the current and future climates, should be adequately maintained and monitored. Nduche *et al.* (2023) reported that Niokolo Koba National Park, Senegal, a reserve site in PA had the highest number of CWR among eleven reserve site found in the West African existing PA network. The authors further identified PA and genetic reserve sites, where West African CWR can be conserved in the region. The negatively affected CWR are members of their related crop genepool and preserving their unique genetic alleles will contribute in widening and strenghtening the genetic resilience in the crops (Maxted *et al.*, 2016; Leigh *et al.*, 2022). Genebanks and field genebanks can serve as complementary measures and back up to the *in situ* conservation. Adequate documentation, and appraisal of accessions and germplam are vital (Khoury *et al.*, 2015; Diez *et al.*, 2018). Community based conservaion through the involvement of local communities can be valuable in identifying (IUCN-WCPA Task Force on OECMs, 2019), managing and conserving CWR. Conserving CWR in living repositories such as botanical gardens for public engagement, and awareness is also needed. Safeguarding of CWR in protected localities and facilities will enhance agricultural development, ensure food security, poverty alleviation and elimination of malnutrition in the region. Conservation effort should be collaborative, involving multiple stakeholders, allowing resources, expertise, and knowledge sharing.

Several biotic and abiotic variables are required in the predictive distribution of CWR under climate change (Anderson *et al.*, 2016). Biotic factor such as such as food web, associations, life cycle, population dynamics, reproduction mechanism, morphological features, seed dormancy, resilient traits, and prevalence of pests and diseases, were not used in the modeling (Leach *et al.*, 2016; Yokoya *et al.*, 2017). Competition with other plant species can drive the evolution of traits, that make CWR resilient and adaptive. Allelopathy, the release of chemicals that inhibit the growth of competing plants can confer an advantage. Severe infestation by pathogens can threaten the survival of CWR populations, reducing their ability to colonize potential new areas (Atwell *et al.*, 2014; Anderson *et al.*, 2016). Certain physiological features like heat tolerence are perculier to some taxa and may affect their response to climate change (Prasad *et al.*, 2016). The interaction among these factors determine the overall structure and dynamics of the ecosystem. However, it is pertinent to know that climate change is a major contributory factor in determining the future threat and extiction risk of CWR. Appropriate distribution range is critical for species survival. The use of a moderate optimistic scenatio (SSP 245), a persimistic scenario (SSP 585) and two timepoints, allowed a more reliable prediction than the use one senario and timepoint (Dormann *et al.*, 2013; Barlow *et al.*, 2021). The use of only the moderate optimistic scenario alone could overestimate the impact of climate change on the CWR (Di Nuzzo *et al.*, 2021).

To effectively mitigate the impact of climate change on West African CWR, the following recommendations are proposed:

1. Carry out occurrence data search for the 26 CWR that had no occurrence data (Table 5S1), in their countries of distribution (Nduche *et al.*, 2023). Areas of predicted distribution created by the SDM can help in locating the sites of the target taxa populations.
2. Conduct field survey for the five taxa that failed the SDM validation test (*Digitaria barbinodis* Henard, *Dioscorea schimperiana* Hochst. ex Kunth, *Ipomea chrysochaetia* Hallier f., *Oryza glaberrima* Steud., *Vigna desmodiodes* Wilczek), the eight taxa that had less than 10 occurrence data (*Dioscorea abyssinica* Hochst. ex Kunth, *Manihot dichotoma* Ule, *Dioscorea*

baya De Wild., *Triticum turgidum* L., *Vigna unguiculata* subsp. *pawekiae* Pasquet, *Vigna unguiculata* subsp. *pubescens* (R.Wilczek) Pasquet, *Ipomoea occhracea* (Lindl.) Sweet, *Dioscorea bulbifera* L.) (Table 5S1 and 5S2)

3. Carry out ecogeographic characterization work to determine taxa and populations with unique and resilient traits and genes to adapt and thrive under climate change conditions, and use of modern techniques such as genome editiing, cisgenesis, intragenesis, epigenetic methods, etc to facilitate their use. Also make crosses between the CWR that are positively affected by climate change such as *Cola angustifolia*, *Dioscorea alata* and *Vigna oblongifolia* with their related crops to develop resilient and climate change adaptive hybrids.
4. Protected areas situated in taxon-rich areas that are predicted to remain under climate change should serve as climate change refugia for the conservation of target taxa populations to ensure their survival.
5 Prioritize the collection mission of the seven CWR predicted to be negatively affected by climate change (*V. unguiculata* subsp. *Letouzeyi, Vigna filicaulis*, *Dioscorea burkilliana, Vigna luteola, Oryza brachyantha*, *Oryza longistaminata*, and *Sorghum purpureosericeum*)

5. Periodically review and revise the recommendations mentioned above with future changes in climate and environmental conditions, availability of occurrence data, availability of updated climate data, and new species distribution modeling tools.

5.6 Conclusion

This study evaluated the impact of climate change on 63 priority West African CWR, under predicted current and future climate conditions. The predicted impact of climate change varied amongst the taxa, between the scenarios and timelines. Seven taxa related to four crops were negatively affected by climate change. Some of the CWR affected have confirmed uses in crop improvement and can help adapt their related crops to climate change effects. The impact of climate change on CWR has far-reaching consequences on global food security and biodiversity (Mirzabaev *et al.*, 2023). Climate change poses a threat to the survival of many CWR species, which play an important role in providing genetic resources for crop improvement and adaptation. The loss of these wild relatives could hinder the development of resilient and climate-smart crops, limiting food provision in particular under marginal environmental conditions (Renzi *et al.*, 2022). There is an urgent need for conservation of the affected taxa to preserve their genetic diversity and ensure their availability for future use. Protected areas in the predicted current and future taxon-rich areas should be adequately maintained and monitored. *Ex situ* collection missions should be conducted for the seven affected taxa. The CWR that are positively effected by climate change can be use in the improvement of their related crop against marginal environment through gene transfer. Stakeholders in the region such as breeders, farmers, government ministries, research institutes, and non-governmental organizations, should work collaboratively to ensure the active conservation of CWR.

CHAPTER: 6

THREAT ASSESSMENT OF WEST AFRICAN PRIORITY CROP WILD RELATIVES

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6.1 ABSTRACT

Crop wild relatives (CWR) threat assessment focuses on extinction risk appraisal and is important in CWR prioritization, inventorying, and conservation planning. In West Africa, only a relatively small number of CWR have been threat - evaluated using the International Union for Conservation of Nature (IUCN) criteria and categories. CWR are wild-related taxa of crops with natural reservoirs of resilient and adaptive genes for improving crop varieties and mitigating the impact of pests, diseases, and climate change. In this study, 24 West African priority CWR were threat evaluated, using the IUCN Red List Categories and criteria. The assessed CWR are related to six crops: White Guinea yam, Barnyard millet, finger millet, teff, sweet potato, and sugarcane. The taxa were assessed as follows: 17 (70%) Least Concern (LC), 3 (12.5%) as Vulnerable (VU), 1 (4.16%) as Endangered (EN) and 3 (12.5%) as Data Deficient (DD). The 24-threat assessed CWR were found in 35 different habitats, with all the CWR occurring in more than one habitat. The major threats to the CWR are invasive species, urbanization and shifting cultivation practices. The current study constitutes a substantial increase in the number of threats assessed CWR in West Africa. The outcome of this study will facilitate the safeguarding and monitoring of West African priority CWR for sustainable utilization in crop modification and to prevent their extinction.

Key words: Threat assessment, Crop wild relatives, IUCN, Conservation.

6.2 INTRODUCTION

Currently, 150, 000 species have been Red List threat assessed using the IUCN criteria, and 24,914 were threatened. In West Africa, 13,834 plant species were threat assessed with Nigeria and Cote d'Ivoire having the highest number of risks assessed, 1,846 and 1,456, respectively. Of these, 1074 plant species were threatened in West Africa, with Nigeria and Guinea having the highest number of threatened plant species, 258 and 221 respectively (IUCN, 2023). The IUCN has provided wide and easy-to-use criteria and categories for the threat assessment of organisms. It aims at providing a concise and precise delineation of species according to their extinction risk. It is a uniform framework and foundation for the threat risk evaluation of organisms. The threat risk levels of species are classified using the principles in the assessment criteria and categories. The eight categories in IUCN threat assessment are: Extinct (EX), where it is confirmed that no individual of the target taxon is still alive, Extinct in the wild (EW); when the taxon cannot be found in the wild, but exist in captivity or outside its past range; Critically Endangered (CR) when it is under extreme or exceptionally high risk of extinction in the wild; Endangered (EN), the taxon is under a very high threat of disappearance in the wild. The vulnerable (VU) taxon is at high risk of disappearance in the wild, while Near Threatened (NT) taxon is close to being threatened; Least Concern (LC), the taxon is abundant and wildly spread.

A taxon is considered Data Deficient (DD), when there is insufficient data to risk assess its populations and distribution, while Not Evaluated (NE) is when a taxon has not been risk assessed against the IUCN threat criteria. The IUCN's five criteria for assessing threat are (A) population reduction, (B) geographic range in the form using the extent of occurrence and/or area of occupancy, (C) small population size and decline, (D) very small or restricted population and (E) quantitative analysis. Extent of occurrence (EOO) is the area within the shortest continuous imagery space which can be drawn to contain all projected area of present occurrence of a taxon, except for circumstances of vagrancy, while area of occupancy (AOO) is the area within the extent of occurrence, occupied by a taxon, except the area of vagrancy (IUCN, 2012a).

Threat assessment also aids in providing data for conservation prioritization of CWR (Willis, 2017). It can be used as input data to the hierarchical evaluation under present and predicted future circumstances surrounding the demography, distribution and habitat of target taxa. CWR risk evaluation and categorization, using IUCN standards and methods is a critical step in active conservation action (IUCN Standards and Petitions Committee, 2022). The IUCN threat categories given to a taxon can be used to prioritize for conservation prioritization (Maxted and Kell, 2009). This conservation prioritization and implementation can be used to improve conservation status so in turn the threat category of the taxa and even prevent further threats to the species.

CWR are plant taxa closely related to crops and are a subset of plant genetic resources, with a large diversity of valuable genes for crop improvement (Maxted *et al.*, 2006). These valuable and novel genes can be introgressed into crops to confer high yield, increased seed weight, fruit size, improved drought, and heat resistance and many other adaptive traits. They are also the progenitors of crops with genetic resources for climate change mitigation and the provision of ecosystem services (Dempewolf *et al.*, 2017). They are substantially more genetically and evolutionary diverse and resilient than crops (Maxted *et al.*, 1997b; Tobón-Niedfeldt *et al.*, 2022). CWR are threatened by climate change pressure, anthropogenic disturbances, urbanization, overgrazing, habitat loss, and fragmentation. The persistent and unpredictable rise in temperature and erratic precipitation pattern is facilitating the continuous decline in the suitable habitat of CWR. Similarly, industrialization, deforestation, and agricultural activities have resulted in the habitat loss of most CWR (Vincent *et al.*, 2013; Magos Brehm *et al.*, 2017a). The growth in human population and urgent need for food is demanding increased intensive production including greater use of herbicides and leading to CWR habitat loss and fragmentation. Jarvis *et al.* (2008) reported that about 16 to 22% of peanut, potato, and cowpea CWR are predicted to go extinct by 2055, due to climate change, while the habitat of maize CWR is predicted to be severely reduced by 50% over the coming years (Ureta *et al.*, 2011).

A previous assessment of CWR taxa focused on the assessment of 224 Mesoamerican CWR related to nine crop genepools Tobón-Niedfeldt *et al.* (2022) reported, that 35% of the taxa were threatened, seven are CR, 47 are EN, 16 are VU, while nine are NT. While, Kell *et al.* (2012) assessed 591 European CWR belonging to 25 crop genepools, the result showed that 66 (11.5%) are Threatened, 19 (3.3%), are CR, 22 (4.4%) are EN, while 26 (4.5%) are NT.

The aim of this study is to threat assess 24 West African priority CWR at the global level, and so: (a) identify the IUCN threat categories of the CWR (b) identify the population trend and species distribution of the taxa and (c) identify the major threats to CWR populations and (d) give input for improving the planning for active conservation, management, and monitoring of the priority CWR.

6.3 MATERIALS AND METHODS

6.3.1 Priority taxa

A checklist of 1651 CWR related to crops were compiled for West Africa, and 102 were prioritized for active *in situ* conservation (Nduche *et al.*, 2021). West Africa being defined here to include, Benin, Burkina Faso, Cote d' Ivoire, Gambia, Ghana, Guinea, Guinea Bissau, Liberia, Mali, Mauritania, Niger, Nigeria, Senegal, Sierra Leone, and Togo. Due to time limitations and to avoid overlapping of with existing threat assessments, 24 taxa belonging to the highest priority CWR from 7 genera and 3 families were threat evaluated using the IUCN threat assessment methodology aided by the species information service (SIS) (IUCN, 2023)

6.3.2 Threat Assessment Process

The 24 West African priority taxa were threat evaluated at the global level, so encompassed all known native distributions of the CWR. Information on the distribution, population, threat, conservation, ecosystem services, occurrence, habitat, ecology, use, and trade of the 24 taxa were collated. Information was collated from various sources such as published research papers, herbarium specimens, field guides, personal communication with genus experts, monographs, online databases such as Germplasm Resources Information Network (GRIN) Taxonomy, Global Biodiversity International Facility(GBIF), Royal Botanic Garden Kew, RainBio, GENESYS, Plants of the world online (POWO) (https://powo.science.kew.org), Plant List (https://www.plantlist.org), World Checklist of Selected Plant Families (WCSP) (https://wcsp.science.kew.org/cite.do), Harlan de Wet diversity (https://www.cwr.diversity.org/checklist/), IUCN, New York Botanical Garden (NYBG), Flickr, African Plants – A Photo Guide, Missouri Botanic Garden and Bioversity International. Locational data were sourced from GBIF, GENESYS, IUCN, RainBio, and NYBG. Using the GeoCAT, the A00 and EOO were calculated based on a grid size of 2 X 2 km and passport data within their area of geographic distribution (Bachman *et al.*, 2011). The number of locations, continuing decline in locations, extreme fluctuations in the number of locations, elevation, depth, biographic realm, and hotspot information for each taxon were compiled. Information on populations of each taxon was calculated, including current population trend, number of mature individuals (population size), severe fragmentation, current trend data derivation, extreme fluctuations, and continuing decline in mature individuals. Similarly, information on the habitat; continuing decline in area, extent and quality of habitat, maximum extent of suitable habitat (ESH), land cover, life history, and movement pattern were calculated. Use and trade of the threat-assessed taxon included non – non-consumptive use of the species and livelihood information. The threat data compiled are on the taxon's past, ongoing, and predicted future threats. The information on distribution, occurrence, population, threat, conservation, habitat ecology, use, and trade, together with the IUCN criteria were used to calculate the threat categories of the selected priority taxa.

6.4 RESULTS

The 24 CWR that were threat assessed belonged to 3 families, 7 genera, 23 species, and three subspecies. The assessed CWR are related to six crops: White Guinea yam, Barnyard millet, finger millet, teff, sweet potato, and sugarcane. Sweet potato and yam gene pools have the highest number of threats assessed CWR, with 8 and 5 respectively (Table 6.1). 17 (70%) taxa were assessed as Least Concern (LC), 3 (12.5%) as Vulnerable (VU), 1 (4.16%) as Endangered (EN) and 3 (12.5%) as Data Deficient (DD) (Fig. 6.1). The EOO ranged from 27, 241 km^2 in *Digitaria barbinodis* to 276, 688, 054 km^2 in *Ipomoea asarifolia*. The taxa with the highest EOO are *I. asarifolia*, *Eragrostis unioloides* and *Dioscorea bulbifera*, with EOO of 276,688,054 km^2, 265,616,532 km^2 and 240,704, 017 km^2, respectively. The AOO, ranged from 16 km^2 in *D. barbinodis* to 17, 144 km^2 in *Eleusine indica* (Table 6.1).

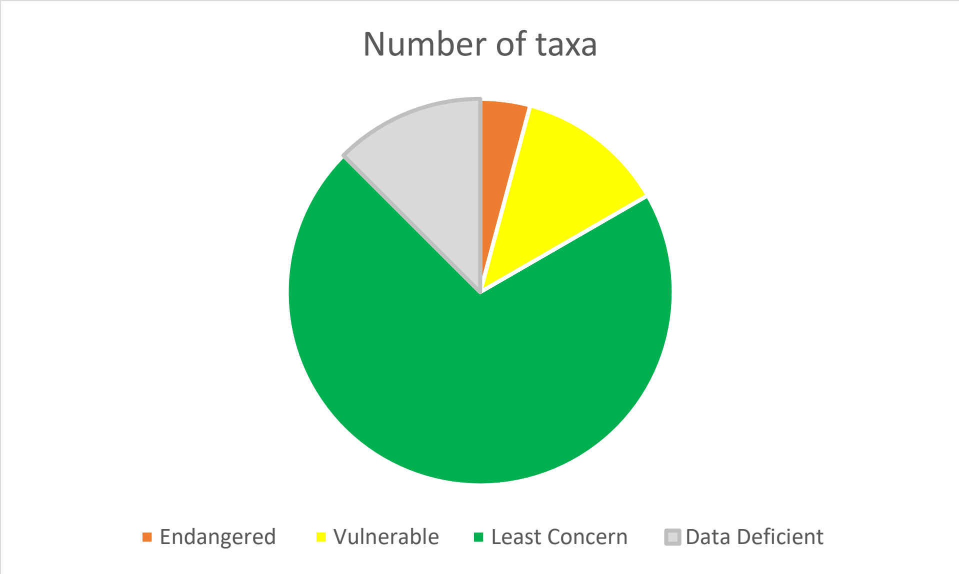

Fig. 6.1: Percentage of the categories of the threat assessed priority CWR

Table 6.1: The global area of occupancy (AOO), extent of occurrence (EOO) and threat to the threat assessed West African CWR

S/N	List of taxa	AOO (Km2	EOO (Km2)	IUCN Category	Related crop	Threat
1	*Digitaria barbinodis* Henrard	16	27,241	Vulnerable (VU)	Fonio	Urbanization and changing cultivation practices threaten the population of this species (Erickson - Davis, 2022)
2	*Digitaria ciliaris* (Retz.) Koeler	11,308	209,852,493	Least concern (LC)	Fonio	No major threats are known to this species
3	*Digitaria fuscescens* (J. Presl) Henrard	88	119,080	Data Deficient (DD)	Fonio	No major threats are known to this species
4	*Digitaria iburua* Staf	20	211,991	Vulnerable (VU)	Fonio	No major threats are known to this species; however, the area of occupancy is significantly reduced
5	*Dioscorea alata* L.	888	53,665,554	Least concern (LC)	White Guinea yam	There are no significant threats to the species. However, certain cultivars which are losing

						popularity may be threatened with extinction; this requires further study.
6	*Dioscorea bulbifera* L.	6944	240,704,017	Least concern (LC)	White Guinea yam	No significant threats. However, this species tends to be invasive
7	*Dioscorea cayanensis* Lam.	2,572	2,506,291	Least concern (LC)	White Guinea yam	This is an invasive species with no known threat.
8	*Dioscorea sagittifolia* var. *lecardii* (De Wild.) Nkounkou	116	6, 426, 610	Least concern (LC)	White Guinea yam	Potential threats to this species are drought, climate change, and agricultural expansion leading to the loss of distribution range (Walther, 2021)
9	*Dioscorea sansibarensis* Pax	440	13,117,669	Least concern (LC)	White Guinea yam	No known threats
10	*Echinochloa crus – galli* (L.) P. Beauv	4,260	61,515,764	Least concern (LC)	Barnyard millet	There is no known significant past, ongoing or future threats to this species
11	*Eleusine africana* Kenn- O'Byrne	1,776	20,202,997	Least concern (LC)	Finger millet	There are no known threats to this species
12	*Eleusine indica* (L.) Gaertn.	17, 144	64,967,625	Least concern (LC)	Finger millet	There is no known threats to this species
13	*Eragrostis pilosa* (L.) P. Beauv.	15,080	100,363,428	Least concern (LC)	Teff	There is a slow decline in the distribution range of the species
14	*Eragrostis unioloides* (Retz.) Nees ex Steud.	1,180	265,616,532	Least concern (LC)	Teff	No known threats
15	*Ipomoea acanthocarpa* (Choisy) Hochst. ex Schweinf. & Asch	20	15,468,310	Endangered (EN)	Sweet potato	No major threats are known to this species, however, the area of occupancy is significantly reduced
16	*Ipomoea argentaurata* Hallier f.	288	2,297,022	Least concern (LC)	Sweet potato	This is an invasive species, with no known threats.

17	*Ipomoea asarifolia* (Desr.) Roem. & Schult.	2,736	276,688,054	Least concern (LC)	Sweet potato	This is an invasive species with no known threats
18	*Ipomoea barteri* Baker	216	3,083,974	Least concern (LC)	Sweet potato	The potential threats to *Ipomoea barteri* Baker are agricultural expansion and urbanization and mining activities (Walther, 2021)
19	*Ipomoea blepharophylla* Hallier f.	220	5,371,070	Least concern (LC)	Sweet potato	There is no known threat to this species
20	*Ipomoea chrysochaetia* Hallier f.	56	5,479,951	Data Deficient (DD)	Sweet potato	There is no known threat to this species
21	*Ipomoea coptica* (L.) Roth ex Roem. & Schult.	132	33,095,018	Least concern (LC)	Sweet potato	There is no known threat to this species
22	*Ipomoea prismatosyphon* Welw.	160	3,340,315	Least concern (LC)	Sweet potato	No specific threats have been recorded, although there is a slow decline in miombo in parts of the distribution area
23	*Saccharum spontaneum* subsp. *spontaneum* L.	24	101,080	Vulnerable (VU)	Sugarcane	Invasive species and decline in area of occupancy
24	*Saccharum spontaneum* subsp. *aegytiacum* (Willd.) Hack.	48	3,170,664	Data Deficient (DD)	Sugarcane	There is no known threats to this species

The threat assessed CWR were found in 35 different habitats. They occurred more in moist tropical / subtropical shrubland and moist savanna. These were occupied by 11 and 10 taxa, respectively. All the 24 CWR occurred in more than one habitat (Table 6S1). *Eragrostis unioloides* occurred in 22 habitat types, while *Eleusine indica* and *Echinochloa crus – galli* occurred in 12 habitats each. Habitats occupied by only one taxon include artificial / terrestrial -urban areas, shrub dominated inland wetland, tropical/ subtropical moist montane forest, tropical/ subtropical mangrove vegetation forest above high tide level, tropical / subtropical dry forest, temperate desert, artificial / terrestrial rural gardens, artificial / terrestrial pastureland, artificial/aquatic ponds, and artificial / aquatic open excavations.

Table 6.2: Number of threat assessed West African CWR present per habitat type

S/N	Habitat type	Number of taxa
1	Shrubland – subtropical/tropical moist	11
2	Savanna – moist	10
3	Wetlands (inland) – Permanent freshwater marshes/pools (under 8ha)	5
4	Shrubland – subtropical/tropical dry	5
5	Artificial/aquatic – seasonally flooded agricultural land	4
6	Wetlands (inland) - seasonal/intermittent irregular river/streams/creeks	4
7	Wetlands (inland) - seasonal/intermittent freshwater marshes/pools (under 8ha)	4
8	Wetlands (inland) – bogs, marshes, swamps, ferns, peatlands	4
9	Grassland – subtropical/tropical seasonally wet/flooded	4
10	Forest – subtropical/tropical moist lowland	4
11	Artificial/terrestrial – subtropical/tropical heavily degraded former forest	4
12	Artificial/terrestrial – arable land	4
13	Artificial/aquatic – irrigated land (includes irrigation channels)	4
14	Shrubland – subtropical/tropical high altitude	3
15	Shrubland – Mediterranean – type shrubby vegetation	3
16	Savanna – dry	3
17	Grassland – subtropical/tropical high altitude	3
18	Artificial/terrestrial – plantation	3
19	Artificial/aquatic – canals drainage channels, ditches	3
20	Wetlands (inland – permanent rivers/streams/creeks (includes waterfalls)	2
21	Wetlands (inland) – permanent freshwater lakes (over 8ha)	2
22	Rocky areas (eg. Inland cliffs, mountain peaks)	2
23	Grassland – subtropical/tropical dry	2
24	Desert – hot	2
25	Artificial/terrestrial – urban areas	2
26	Wetlands (inland) – shrub dominate wetlands	1
27	Forest – subtropical/tropical moist montane	1

28	Forest – subtropical/tropical mangrove vegetation above high tide level	1
29	Forest – subtropical/tropical dry	1
30	Desert – temperate	1
31	Artificial/ terrestrial – rural gardens	1
32	Artificial/ terrestrial – pastureland	1
33	Artificial/aquatic – wastewater treatment areas	1
34	Artificial/aquatic – ponds (below 8ha)	1
35	Artificial/aquatic – excavations (open)	1

D. fuscences, D. cayanensis, I. argentaurata, I. asarifolia, Saccharum spontaneum subsp. *spontaneum* are threatened by invasive species, while *D. barbinodis* is threatened by urbanization and shifting cultivation practices. The areas of highest species richness for the threatened species in West Africa were found in Colline, Kouffou, and Zou provinces of Benin and Plateaux region of Togo (Fig. 6.2), while the highest species richness for DD taxa were found in Southwest Nigeria (Fig. 6.3). Other areas of species' distribution of threatened species are Senegal, Guinea – Bissau, Cote d'Ivoire, Burkina Faso, Ghana, Nigeria, and Niger (Fig. 6.2). Six of the assessed taxa were updated previous assessments as they were assessed 5 years ago. The updated taxa are *I. coptica*, *I. prismatosyphon*, *E. crus - galli, E. africana, E. indica* and *E. unioloides* but, the threat categories of the updated assessment was unchanged.

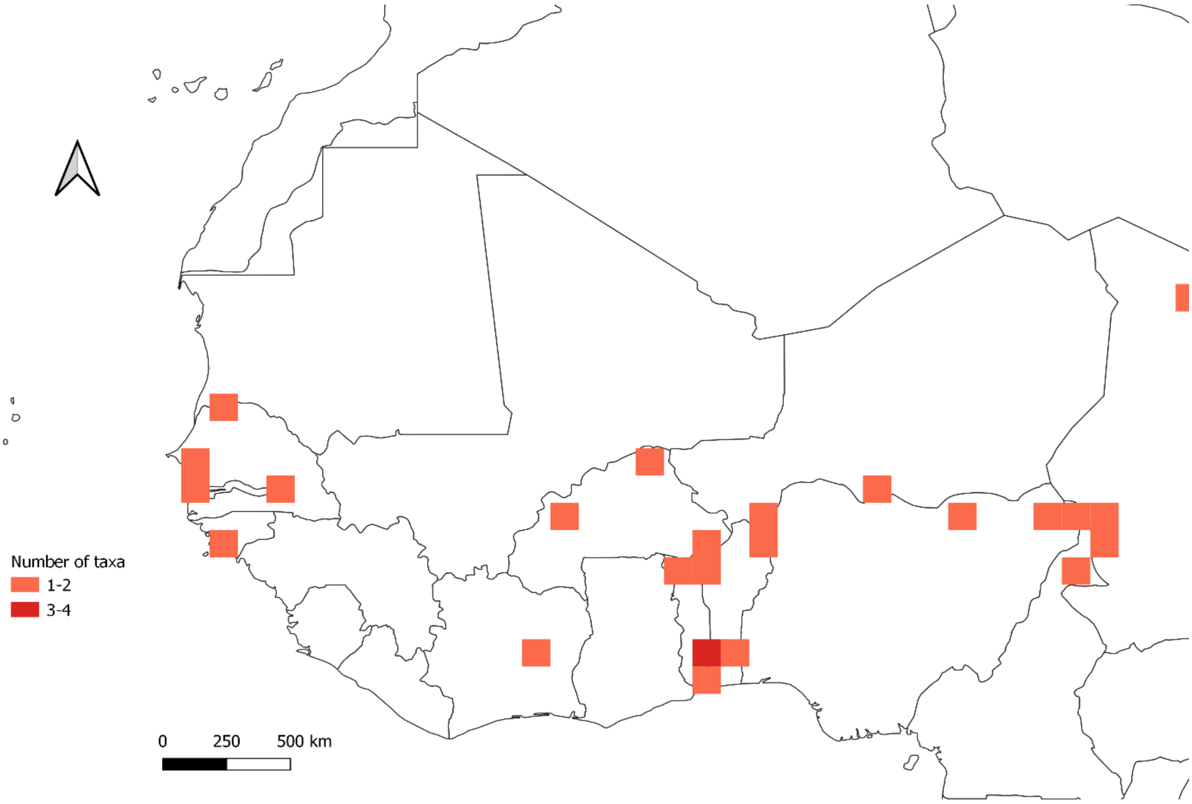

Fig. 6.2: Species distribution of threatened species

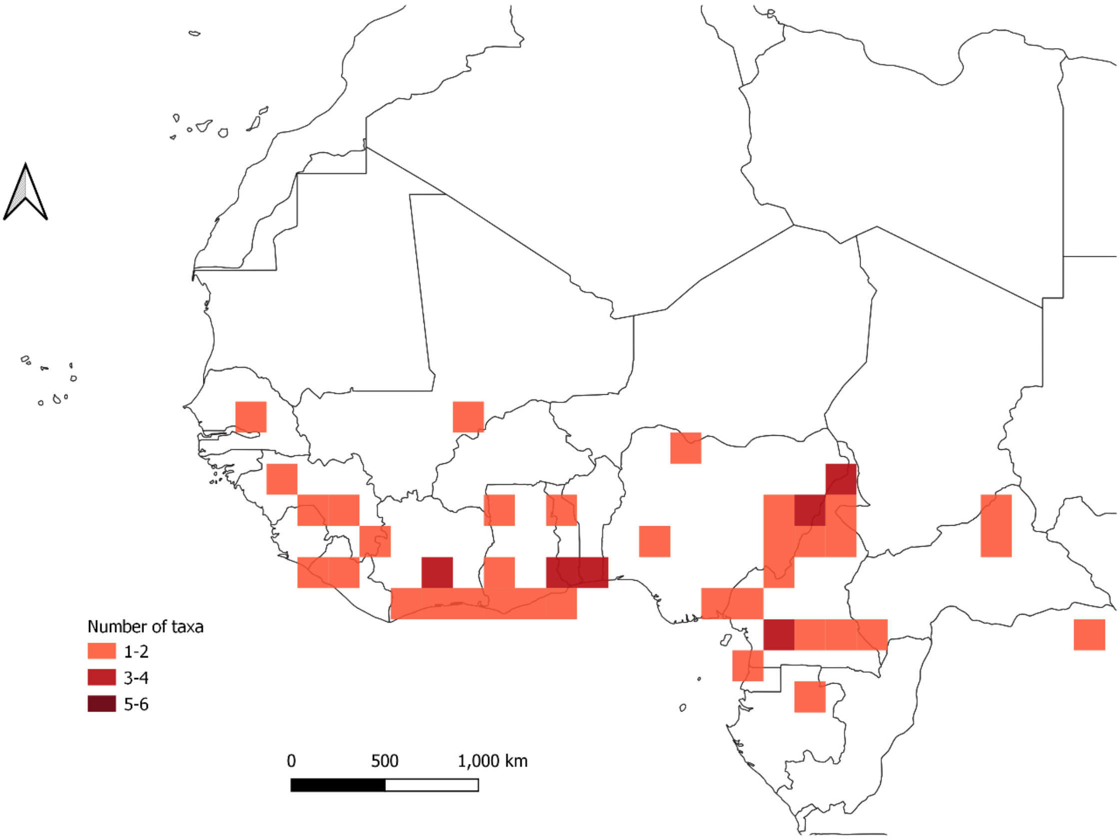

Fig. 6.3: Species distribution of Data Deficient species

6.5 DISCUSSION

The outcome of this study, where the threatened taxa represent 16.6% of the assessed CWR is in line with (Kell *et al.*, 2012), where 11.5% of the 572 threat-assessed European priority CWR were threatened, 3.8%, 4.4%, and 3.3% were VU, EN and CR, respectively. Similarly, Contreras-Toledo (2019) reported that 8.3% of assessed Mexican priority CWRs were threatened, 5% were VU, 18% EN and 1% CR. Among the crops related to the assessed CWR, sweet potato, White Guinea yam and fonio had the highest number of assessed CWR; 8, 5 and 4, respectively. The assessed CWR taxa can be used for the improvement of their related crops to ensure food security in the region. *D. ciliaris* is consistent with the LC category in the regional assessment of United Arab Emirate (UAE). However, *E. pilosa*, assessed as DD in regional assessment of UAE, was assessed as LC in this study. *E. pilosa* populations have the highest occurrence by country, occurring in 123 countries across Asia, Africa, Europe, Oceania, North and South America. Conversely, *Digitaria barbinodis* has the least occurrence, occurring in only two countries: Nigeria and Mali. The two endangered species in the genus *Digitaria*, assessed as endangered, as reported by IUCN (2023) assessed 12 other *Digitaria* species as endangered.

The area of species distribution of the threatened taxa corresponds to the area of diversity hotspot of West African priority CWR, which were located in Benin, Ghana, Nigeria and Cote d'Ivoire (Nduche *et al.*, 2023). This also agrees with the report of POWO (2021) that the four threatened CWR in this study are natïve to Benin, Cote d' Ivoire, Guinea – Bissau, Guinea, Burkina Faso, Nigeria and Niger. The highest species richness were found in Colline, Kouffou and Zou provinces of Benin and Plateaux region of Togo (Fig. 6.2). It is pertinent to know that Acheerighe, Djigbe, Gougoun, Ketou, La Lama Nurd, LaLama Sud and Logozohe National parks, Benin and Amakpave, Togo are in these areas. Resources can be allocated to these sites with highest species richness for the conservation of these threatened taxa. Nduche *et al.*, (2023) reported the presence of *Ipomoea acanthocarpa* and *Digitaria iburua* in Aticherigbe national park, Benin, and Oti - keran, Togo, respectively. 45% (11) of the assessed taxa were found in shrubland – subtropical/tropical moist habitat, while 41.7% (10) of the taxa were found in savanna moist habitat. Savannah is one of the important vegetations in the world. In Africa, it covers 65% of the region and a wide vegetative zone in West Africa. It spans from the Sahel savannah to the tropical rainforest, providing ecosystem services (Grace *et al.*, 2006). It sustains livelihood by supporting agricultural production and grazing activities and is obviously an important habitat for CWR taxa. Pooter *et al.* (2004) reported that a majority of West African floristic diversity is found in the rain forest, which harbours endemic and rare plant species. A study by Holmgren and Poorter (2007) on the distribution of 216 vascular plants showed that a third of the plants were found in tropical rain forest with most species restricted to moist environment where there is availability of water.

Threat status has been widely considered as a tool for prioritization of CWR in conservation planning (Ford-Lloyd, 2011; Magos Brehm *et al.*, 2017b). There is need for active conservation of the four threatened taxa (*Digitaria barbinodis* Henrard, *Digtaria iburua* Staf, *Ipomoea acanthocarpa* (Choisy) Hochst. ex Schweinf. & Asch and *Saccharum spontaneum* subsp. *spontaneum* L.) identified in this study. Drechsler *et al.*, (2011), reported that, in reality, conservation mostly commence when species are already at the verge of extinction, with only few populations left. Such delay in conservation action, further increases extinction risk and put conservation practitioners under pressure to restore the population of such taxa. This scenario is recorded in *Amaranthus brownii*; a Hawaiian Island plant, *Fissidens microstictus*; a Portuguese Island plant and *Angraecopsis dolabriformis*; a plant native to the Island of Sao Tome and Principe, which were in existence four decades ago, but now in extinction (Bruegmann *et al.*, 2018; Simo *et al*., 2018 and Sim – Sim *et al.*, 2019). Other recently extinct plant species are *Trilepidea adamsii* (Adams mistletoe); a New Zealand's North Island plant, and *Acalypha dikuluwensis*, a DR Congo native plant which were found six decades ago, but have been declared extinct (de Lange, 2014; Meersseman *et al.*, 2018). Rapid assessment is also critical in identifying species at the risk of extinction as it reveals the major threats to taxa, which could be averted for the recovery of the threatened plant species. There is urgent need to develop integrated safeguarding strategies to preserve the rich diversity of CWR for sustainable utilization and for the benefit of the future generation (Vincent *et al.*, 2013).

The major threats to two of the threatened West African priority CWR included in this study are invasive species, urbanization, and changing cultivation (Table 6.1). This agrees with the report by IUCN (2015), that urbanization, agricultural expansion; hunting, and exploitation of natural resources are the major causes of habitat loss in West Africa. Tobón-Niedfeldt *et al.* (2022), reported that agriculture and invasive species are the highest threat to Mesoamerican CWR affecting 65% and 38% of the taxa, respectively. Kell *et al.*, (2012) reported that housing and urbanization are among the most common threats to European CWR. The demand for more farmland for agricultural activities and urbanization through housing are major threats to CWR, especially in West Africa where agriculture is the main source of livelihood. Overpopulation has been identified as the major cause of urbanization in West Africa. The area occupied by housing in West Africa has increased by 44% over the last four decades (Herrmann *et al*., 2020). This will significantly impact negatively on the distribution and survival of CWR in the region.

6.6 CONCLUSION

A total of 13, 834 taxa have been risk assessed in West Africa, and the threat evaluation in this study will increase the number to 13, 852 without including taxa updated from previous assessment. 17

(70%) taxa were assessed as LC, 3 (12.5%) as VU, 1 (4.16%) as EN and 3 (12.5%) as DD. The threat assessed CWR were found in 35 different habitats ranging from shrub land – subtropical/tropical moist to artificial/ terrestrial – rural gardens. Threats to the CWR are invasive species, urbanization and changing cultivation practices. Implementation of active *in situ* and *ex situ* conservation actions and prevention of threats for the priority CWR will ameliorate the extinction risk and increase the availability for use in crop improvement to ensure food security.

CHAPTER 7

GENERAL DISCUSSION

This study presents the development of the scientific basis of a West African CWR conservation strategy to promote sustainable utilization in crop improvement and ensure food security in the region. CWR are novel resources with unique traits that can be used to adapt crops to climate change (Yadav *et al.*, 2015; Phillips *et al.*, 2017). The West African region has been characterized by poverty, and afflicted by lack of food provision and malnutrition. This work reveals the priority CWR, native to the region that can serve as pre-breeding aids for the improvement and modification of socioeconomically valuable crops in West Africa. The priority CWR considered in this study are related to crops that form the daily diet and calories of the region's populace. This work is, therefore, a significant contribution in the food provision and agricultural productivity in the region and beyond. The study emphasizes the urgent need to conserve priority CWR to ensure their continued availability for future use. Food and nutrient provision is a major component of the United Nations Sustainable Development goals (United Nations, 2015a) in target 2.5 where the need for the protection and management of crops and their wild diversity is stressed: ''By 2020, maintain the genetic diversity of seeds, cultivated plants, farmed and domesticated animals and their related wild species, including through soundly managed and diversified seed and plant banks at the national, regional and international levels, and ensure access to and fair and equitable sharing of benefits arising from the utilization of genetic resources and associated traditional knowledge as internationally agreed''. CWR also more recently have been included in the United Nation's Intergovernmental Science – Policy Platform on Biodiversity and Ecosystem Services (IPBES, 2019) and the Kunming – Montreal Global Biodiversity Framework calls for ''Target 4: Ensure urgent management action to halt human induced extinction of known threatened species and for the recovery and conservation of species, in particular threatened species, to significantly reduce extinction risk, as well as to maintain and restore the genetic diversity within and between populations of native, wild, and domesticated species to maintain their adaptive potentials, including through *in situ* and *ex situ* conservation'' (CBD, 2022). These legislative frameworks prescribe the priority conservation of genetic diversity for food security and climate change adaptation. It recognized that the genetic diversity of cultivated plants and their wild relatives, including other socioeconomically and traditionally useful plants needs to be conserved. West Africa accounts for 5.47% of the total world population, with annual growth rate of 2.59 in 2020 (Worldometer, 2023). The rapid growth for the population projected for the coming decades will severely impact the region's ability to supply food to it's populace. The percentage of undernourished people in West Africa is 30.9%, which is higher than the global average of 22% (Global Nutrition Report, 2022). The use of CWR in improving crops for abundant food production is a natural and promising approach to meet the rising food demand in the region.

The method for the CWR conservation described by Maxted *et al.* (2008b) was used in the development of the CWR strategy for West Africa (Nduche *et al.*, 2023). This method has been used in CWR conservation priorities for other regions such as Southern Africa Development Commission (SADC) (Allen *et al.*, 2019), Northern Africa (Lala *et al.*, 2018), and the Fertile Crescent (Zair *et al.*, 2017). West Africa is a heterogeneous and diverse region with several wild and endemic plant taxa. It is characterized by abundant ecological diversity with resilient plant species that harbour novel genes for crop improvement. The region has been recognized as one of the centres of crop domestication (Carney, 2001; D'Andrea *et al.*, 2007; Hall, 2008; Leroy *et al.*, 2014; Burgarella *et al.*, 2018; Chomicki *et al.*, 2019), while the Guinean forest is included among the 36 biodiversity hotspots in the world (Conservation International, 2008). A total of 1651 wild plant taxa were compiled into a checklist and subsequently prioritized into 102 priority taxa (Nduche *et al.*, 2021). The CWR checklist was compiled from the flora of West Africa (Huchinson and Dalziel, 1958) and World Checklist of Plant Families (WCSP, 2020). Cultivated taxa with no wild relatives such as maize (*Zea mays* L.), oil palm (*Eleais guineensis* Jacq), cocoyam [*Colocosia esculenta* (L.) Schott], and coconut (*Cocos nucifera* L.) were removed prior to prioritization. There has not been any regional CWR checklist for West Africa prior to this, hence this study. The compiled CWR checklist was prioritized to reduce the number of taxa into manageable number due to constraint of funds. In this study, three criteria were used in the prioritization process (i) CWR value in West Africa from FAOSTAT (ii) CWR closeness to their related crop, and (iii) global threat status according to IUCN. Other criteria that can be used for CWR prioritization include; distribution status, occurrence status, conservation status, population data and genetic diversity information (Vincent *et al.*, 2013; Magos Brehm, 2017). CWR prioritization can be done at different geographical range such as global, regional, and national. The three criteria used in this study are the commonly used criteria and have been applied by other authors such as Idohou *et al.* (2013); Allen *et al.* (2019). The 102 priority CWR selected in this work are not a conclusive and exhaustive list, but they can on the bases of available data be effectively used to prioritize conservation action. As more background data accrues, other taxa may be recommended for further prioritization in the future.

The purpose of CWR prioritization is as basis for active *in situ* and *ex situ* stewardship (Kell, 2016). The parallel use of *in situ* and *ex situ* conservation techniques in the safeguarding of priority CWR is to ensure their maximum availability in the future and to avoid extinction (Maxted *et al.*, 2016). Prioritization precedes the protection of the taxa in the conservation action plan. For effective prioritization and conservation action, information about the priority CWR is required. This includes the related crop use, concept level, their confirmed use, potential use for crop improvement, distribution, socioeconomic value, IUCN category, assessment level, breeding type, life span, life form, presence in PA, *ex situ* sample range (Thormann *et al.*, 2017). The two main approaches to conservation are the application of *in situ* and *ex situ* techniques (Maxted *et al.*, 2008b; Vincent *et al.*, 2019). In *in situ* conservation, the taxa are conserved in their natural habitat, while *ex situ* conservation gives it artificial protection in facilities such as genebank, seed banks, DNA banks, or cryopreservation (Maxted, 2013; Zegeye, 2017). *In situ* conservation enhances natural gene transfer and the perpetual evolution of CWR populations (Hodgkin and Hajjar, 2007). It protects the full breadth of alleles in the genepool for the species survival (Maxted *et al.*, 2016). There is no strong link between the selection of sites for CWR conservation and the actual management of the selected sites. Therefore, there is a need to bring together the agro-diversity conservation community that prioritized the CWR and identified the sites with the conservation communities that manage the network of PA (Magos Brehm *et al.*, 2022).

The *in situ* conservation analysis of West African CWR was reported by Nduche *et al.* (2023). Occurrence records were collected from national and international sources for the priority CWR, compiled and used to create the species distribution, predicted distribution map and complementarity maps. This work may provide relevant information to national and international data sources such as GRIN Taxonomy (USDA, 2021), Harlan de Wet CWR inventory (Vincent *et al.*, 2013), IUCN (IUCN, 2023) and RainBio (Dauby *et al.*, 2016), as they often work with published research papers to assign concept levels to crop genepool. The taxon distribution map showed the area of taxon richness and identifies hotspots, while the predicted distribution maps revealed the potential area of distribution of the priority taxa. The complementarity map was created to identify the potential reserve sites that could complement the existing network of protected areas (Vincent *et al.*, 2019; Magos Brehm *et al.*, 2022). A complementary analysis was carried out and identified 29 potential reserve sites for the conservation of the West African CWR. Apart from Mauritania, Gambia, and Burkina Faso, reserve sites were found in all West African countries. Eleven reserve sites were located in the network of PA. 48.68% (37) of the priority taxa with occurrence data were conserved in 9 of the reserve sites (Nduche *et al.*, 2023). The 18 reserve sites located outside PA should also be established to conserve priority CWR (FAO, 2010), possibly by establishing Other Effective Area-based Conservation Measures (OECMs) (IUCN-WCPA Task Force on OECMs, 2019). However, practically, it should be recognized that the PA networks in West Africa are not adequately maintained, with insufficient personnel and lack of effective legislative frameworks to protect these sites. Due to pressure from overpopulation, hunting, logging, overgrazing, and extensive agricultural practices, PA have been encroached, degraded, and often destroyed (Rodrigues *et al.*, 2004). Stakeholders, PA managers, park rangers, government ministries and other relevant authorities should ensure the maintenance of PA for optimal CWR safeguarding actions, but in the short term, *ex situ* conservation activities should take the lead due to their relative ease of implementation.

Ex situ conservation gap analyses identifies the number of accessions of CWR conserved *ex situ*, the CWR that are not represented in *ex situ* conservation, and the areas that need a further collection (Mponya *et al.*, 2020; Zair *et al.*, 2021; Magos Brehm *et al.*, 2022). 45% (46) of the priority West African CWR are not represented *ex situ*, while 76.7% (43) of the accessions conserved *ex situ* are underrepresented with less than 50 accessions present in genebank. Areas of further *ex situ* collection are found in Assaba and Guidimaka province of Mauritania; Saint Louis and Tambocounda regions in Senegal; Nzerekore region in Guinea; Koinadugu, Bombali and Tonkolili districts of Sierra Leone; Loffa, Bomi, Montserrado and Grand Cape Mount countries of Liberia. Montagnes, Lacs and Lagunes districts of Cote d' Ivoire; Mopti region of Mali; Upper West, Bono East, Eastern, Volta and Ashanti regions of Ghana. Other areas are Haut – Bassins, Cascades, Est and Centre – Est regions of Burkina Faso; Plateau, Queme, Atlantique and Alibori provinces of Benin; North – East and North – Central zones of Nigeria (Nduche *et al.*, 2023). Recent conservation action has been focused on *ex situ* techniques, due to easy access of germplasm for breeding and other forms of utilization. Also, greater diversity of the priority taxa can be conserved as seeds, ovaries which are readily accessed for evaluation and use (Magos Brehm *et al.*, 2017a; Zegeye, 2017). Globally, there are about 7.4 million plant accessions conserved in 1750 genebanks (FAO, 2010).

Ecogeographic diversity is used as proxy for genetic diversity (Parra-Quijano *et al.*, 2012a). Ecogeographic land characterization (ELC) maps are used to determine the ELC zones in an area, while the 'Representa tool' of CAPFITOGEN is used to show the *ex situ* representation of the ELC categories (Parra - Quijano *et al.*, 2021). Taxa found in rare ELC zones are likely to harbour unique genes (Contreras-Toledo, 2019; Parra - Quijano *et al.*, 2021) and should be prioritized for *in situ* and *ex situ* conservation. Eight ELC zones were not represented in genebanks, while four ELC zones had low representation in genebanks (Nduche *et al.*, 2023).

Climate change is already affecting agricultural productivity and livelihood in West Africa. It is one of the threats to crops and their wild relatives (IPCC, 2014, 2021). In this study, the impact of climate change on 68 West African CWR were evaluated using emission scenarios (SSP 245 and SSP 585) at two different time points (2050 and 2070). Seven CWR related to four crops (yam, rice, sorghum, and cowpea) are predicted to be negatively impacted by climate change. Additionally, *V. filicaulis* will be very negatively affected by climate change across all the scenarios and years (SSP 245; 2050, 2070 and SSP 585; 2050, 2070). Conversely, CWR such as *Cola angustifolia*, *Dioscorea. alata* and *Vigna. oblongifolia* are likely to survive well under climate change over all the scenarios and years as climate change is likely to have a more positive impact on them (Chapter 5). This trait suggests that the aforementioned CWR could be used to adapt crops to drought and heat. The effect of anthropogenic climate change on the CWR and their genepool will include the reduction in distribution range, fragmentation of habitat, and change in the physiology of the species (Jarvis *et al.*, 2008; Cobben *et al.*, 2013). Climate change will have an impact on conservation actions, the specific targeting of *in situ* and *ex situ* actions. Existing PA will need to be upgraded due to distribution range shift to accommodate the movement in taxa distribution (McClean *et al.*, 2005). The taxa under threat by climate change should be prioritized for *in situ* and *ex situ* conservation to prevent their extinction. Climate change have already put significant pressure on crop yield, leading to decrease in global food production (Ray, 2019).

CWR threat assessment is essential to identify taxa that are at high risk of extinction and to prioritize them for urgent and active stewardship (Ratnayake *et al.*, 2021). The threat status of CWR is an important criteria in CWR prioritization and conservation planning (Maxted and Kell, 2009; Magos Brehm *et al.*, 2017a; Thormann *et al.*, 2017). IUCN (2023) reported that 13, 834 plan species have been risk assessed in West Africa, out of which, 1074 are threatened. More comprehensive threat evaluations need to be conducted for West African plant species to aid CWR taxa conservation. Specifically, prioritization is required for the remaining unassessed taxa in the CWR checklist to determine their threat status. 24 of the 102 West African priority CWR were threat assessed (Chapter 6). The outcome showed that 4 (16.7%) of the CWR were threatened. The major threats to the assessed West African CWR are invasive species, urbanization and changing cultivation.

The global genepool conservation and use analysis for Dioscorea (Yam) was undertaken to determine the *in situ* and *ex situ* gap in the conservation of yam CWR, propose complementary sites, identify CWR and areas of further *ex situ* collection. In this study, 38 global yam CWR were compiled into a CWR checklist, and by using the criteria of CWR closeness to crop, the CWR were prioritized into 27 CWR. The CWR are related to seven edible yam species and their number per edible species are 17 to Greater / water yam (*D. alata*), 5 for aerial yam (*D. bulbifera*), 25 for yellow Guinea yam (*D. cayanensis*), 5 for bitter yam (*D. dumetorum*), 5 for lesser yam/ Asiatic yam (*D. esculenta*), 12 for white Guinea yam (*D. rotundata*) and one for *D. trifida*. Twenty-four of the priority CWR belong to the secondary genepool (GP2), two CWR; *D. baya* and *D. burkilliana* belong to primary genepool (GP1b). A total of 13 complementary sites were identified with four sites in existing network of PA. Out of the four complementary sites in PA, two are in Asia, one each in Africa and the Oceania. The complementary sites in network of PA were found in Central Africa Republic, Yemen, Thailand, and Australia. Those outside existing PA are in Ethiopia, Nigeria, Democratic Republic of Congo, Madagascar, India, Thailand, and Malaysia. Of the 27 global yam priority CWR, only five taxa do not require further ex situ collection because they have at least 50 accessions in genebanks. The taxa are *D. glabra, D. hispida, D. minutiflora, D. pentaphylla* and *D. praehensilis*. 81% (22) of the priority taxa are conserved *ex situ.* It is noted that FAO (2010) reported that 15, 903 accessions of yam and wild relatives are conserved in 99 facilities in 57 countries.

The development of the scientific bases for the West African CWR conservation and use strategy undertaken in this study will set the foundation for further active conservation of priority CWR in the region. To achieve the aim of active conservation of West African priority CWR, the following recommendations are proposed.

1. The list of 102 priority CWR should be made available to PA managers, PA personnel, genebank curators, breeders, research institutes, Ministries of Agriculture, and other stakeholders in West Africa to highlight their economic value and help ensure their active conservation. They should be monitored and maintained in PA, as well as in genebanks to avoid threat from anthropogenic activities, natural disaster, and climate change.
2. The floristic checklist should be expanded to accommodate more plant families not captured in this study. This will ensure that more CWR diversity is included in future prioritization.
3. The 11 reserve sites located in PA (Niokolo – Koba National Park, Senegal; Boucle de la Pendjari, Benin; Dosso, Niger; Mount Nimba, Guinea; Yankari, Nigeria; Diecke, Guinea; Nasarawa, Nigeria; Eto, Togo; Goudi, Cote d' Ivoire; Eleiyele, Nigeria and Volta River, Ghana) should be upgraded for the active conservation of the West African priority CWR. More PA should be established in countries such as Guinea – Bissau, Mali, Niger, Sierria Leone, and Senegal with few existing PA. For the global genepool conservation for yam, the four complementary sites located in existing PA (Sangha Trinational, Central Africa Republic; Socotra Archipelago, Yemen; Blue Fig Creek, Australia and Namtok Ched Sao Noi, Thailand) should be used for the active conservation of the global yam priority CWR.
4. Collecting missions should be prioritized for the CWR that are not represented in genebanks. Stakeholders from all West African countries should be involved in the collection exercise to ensure that the broadest possible area is covered. There should be knowledge sharing among stakeholders in the region to ensure adequate dissemination of relevant information on the collection programme. This will assist in updating databases containing such records. The collection mission should target hotspot areas such as Atlantique, Littoral, Mono, Kouffo, Akatara, Donga, and Colline provinces of Benin; Accra and Volta regions of Ghana, North – Central zone of Nigeria, Lac district of Cote d' Ivoire and Nzerekore region of Guinea.
5. Due to threat from anthropogenic activities, and natural disasters that is likely to occur in the future, and with additional datasets becoming available, the threat assessment should be

periodically updated. it is suggested that the priority CWR be reassessed after 10 years (IUCN, 2001), with a shorter time period for threatened taxa.

6. Collaborative research among member countries in the West African region should be encouraged to strengthen CWR conservation effort and create an atmosphere for engagement, aimed at the active conservation of CWR in the region. It will involve the complete inventory of CWR native to the region and the design of conservation action plans. Examples are the Nordic countries (NordGen) (NordGen, 2024) and the Southern Africa Development Commission (SADC) (Allen *et al.*, 2017).
7. Other Effective – Area Based Conservation Measures (OECMs) which are Community based conservation approaches should be established to safeguard priority taxa that lack records in existing network of PA. OECMs are areas that are managed to achieve effective and sustained long term *in situ* preservation of biodiversity (IUCN-WCPA Task Force on OECMs, 2019). These areas can be identified using complementary grids; areas in Abidjan, Sassandra – Marahoue, Bas – Sassandra, Lacs districts of Cote d'Ivoire and Niger and Borno states of Nigera. They can also be spotted through stake-holders feedback.
8. The increasing population in West Africa requires adequate food production to secure the nutrient need of the populace. There should be a way to promote the use of CWR to improve crop to meet the rising demand for food by the regions' population. Adequate food production is affected due to lack of linkages between agrobiodiversity researchers, breeders and farmers. *In situ* and *ex situ* conservation networks should be structured in an appropriate manner to intergrate crop breeders into the process. Breeders should have access to the full breath of CWR diversity in breeding programmes. CWR researchers, crop breeders and farmers should work together to realise this objective to ensure food provision in the region. West Africa is well positioned to advance resilient and abundant agricultural production through the use of abundant natural diversity for optimum output.

LIMITATIONS OF THE RESEARCH

One of the limitations to this research is the inconsistencies in the nomenclatural priority of some taxa. The incongruity in the accepted taxa and the synonyms in different taxonomic sources posed a challenge to the study. For instance, USDA (2023) classified white Guinea yam as *D. rotundata* Poir, while POWO (2021) classified *D. rotundata* Poir as a synonym of *D. cayenensis* subsp. *rotundata* (Poir) J. Meige. On the other hand, The Plant List (2023) included *D. rotundata* Poir as a synonym of *Diocorea rosei* R. Knuth and put *D. cayenensis* subsp. *rotundata* (Poir) J. Meige as accepted name. Another example is that, The Plant List (2023) included *Ipomoea prismatosyphon* Welw as a synonym of *I. praematura* Eckenw, while, POWO (2021) classified *I. praematura* as synonym of *I. hederifolia* L.

However, The Plant List (2023) listed *I. hederifolia* L. as the accepted name. Also, The Plant List (2023) included *I. chrysochaetia* as a synonym of *I. chrysocalyx*, while POWO (2021) classified both as accepted names. Nomenclatural confusion is likely to have led to some mistakes over data attribution, though overall this is not thought to have significantly impacted the results presented.

The duplication of occurrence records in data sources and lack of precision in the data, such as the absence of data coordinates, and the wrong collection site assigned to a record, constituted a challenge in occurrence data collation. This affects the number of occurrence data collated and the duration of the collation. The number of occurrence data used in diversity analyses plays a role in the quality of the species richness and complementary maps produced. For instance, more occurrence data will likely generate more reserve sites and the number of CWR in the network of PA (Nduche *et al.,* 2023). A series of studies have shown that the number of occurrence data and bias in data, influences the model performance and quality of map produces (Elith *et al.*, 2006; Hernandez *et al.*, 2006). Similarly, errors and inaccuracies in locational information and occurrence records may lead to under or over-estimation of species range distribution and therefore incorrect extinction risk assessment and inappropriate conservation action (Nic Lughadha *et al.*, 2019; Zizka *et al.*, 2021)

For the impact of climate change on West African CWR, some biotic and abiotic factors were not considered in the analysis to determine the overall effect of climate change. This is because of the unavailability of the file format of such parameters such as life span, population, seed dispersal, pollination, migration, pests, and diseases (Imbach *et al.*, 2017; Das *et al.*, 2018). Competition for space and nutrition, and the prevalence of pests and diseases can limit the survival rate and geographical distribution of taxa, leading to an increase in the negative impact of climate change on taxa. Conversely, pollination and seed dispersal are likely to produce a positive impact of climate change on the species. This will impact results, but ultimately, doing any kind of scientific study, the results can only ever be based on data available at the time.

Selecting the correct models for the hemisphere of the study site can be challenging. Climate models can differ in their grid size level and how they represent physical phenomena such as surface-atmosphere exchanges or vegetation cover. They are reported to give different response information on the impact of climate change on the Earth's atmospheric and terrestrial hemispheres. Certain imperfections in the models can prevent proper simulation of important climate variables such as temperature, precipitation, wind, soil water capacity, solar radiation, etc. In some cases, some climate models may arbitrarily fail to determine the precise effect of the current climate variables (Lissovsky and Dudov, 2021). Also, as global circulation models use mathematical equations to determine how energy and matter interact in different parts of the hydrosphere, atmosphere, and land, discrepancies can arise due to uncertainties and internal assumptions within the species distribution models (Lissovsky and Dudov, 2021) However, based on climate data sources and published papers on previous climate change analyses in West Africa, appropriate models were selected that represent the future permafrost for the region (Stanzel *et al.*, 2018).

FURTHER WORK

Vigna is the genus with the largest number of taxa among the West African priority CWR. Cowpea is also an important staple crop in the region, easy to cultivate with two growing seasons per annum. It provides nutrition; a source of livelihood for subsistent farmers in the region and serve as cover crop for nitrogen fixation. Further work on global genepool conservation strategy for *Vigna* is required for the genus to be further exploited in the future and effectively conserved.

Threat assessment should be conducted for more West African CWR to determine their extinction risk, identify their threats and prioritize their conservation action.

It is important to study the mechanism of gene transfer from CWR to crop for the priority taxa. Biotechnology and molecular research should be undertaken to understand and identify the genes of interest in the wild taxa and the transfer process to ensure that the rich diversity in CWR are transferred to crops to enhance the quality and socioeconomic value of crops.

Public education relating to CWR will help to inform the public on the benefits of CWR conservation and to decrease anthropogenic threat to CWR. This could be in the form of seminars, campaigns, and training programs. It will also harmonize the trend and goal of CWR preservation (Amel *et al.*, 2017; Sparkman and Walton, 2017; Moreau and Novy, 2018)

CONCLUSION

This study provides information and analyses on the development of a CWR conservation and use strategy for West Africa. West Africa is one of the centres of origin and domestication of important crops and it’s among the biodiversity hotspots in the world. This work produced the first regional CWR active conservation plan for West African and included, a checklist, prioritization, inventory, *in situ* and *ex situ* conservation as well as climate change and threat assessment for the priority CWR in the region. The priority CWR will serve a source of diversity breeding for their related crops. It will serve as a guide for the implementation of the conservation strategic plan, and monitoring of the conservation process. Active conservation of the priority CWR will ensure their availability and sustainable utilization to secure food provision under climate change. The study presented above is a pre-breeding tool for major socioeconomic valuable crops in West Africa, through its identification of the priority CWR closely related to them, and indicating where gene transfer is possible. The resilient genes in the CWR have the potential to adapt the related crops to climate change and marginal environmental conditions.

The West African CWR inventory comprising 102 priority taxa was generated from 1651 CWR partial checklist. The prioritization process allowed the CWR that required urgent conservation to be selected. The *in situ* and *ex situ* conservation gap analysis identified the complementary sites for the safeguarding of the priority taxa and the areas of further *ex situ* collection missions. ELC map analysis also revealed the ecogeographic representativeness of the germplasms in the different ELC categories. The ELC categories with few populations are also prioritized for conservation to fill the conservation gap.

The evaluation of climate change's impact on West African CWR through species range change showed the taxa which are most highly impacted by climate change and whose distribution range will be reduced. The extent of reduction in the distribution range is proportional to the severity of the climate change impact. The CWR most impacted by climate change are prioritized for active conservation.

The IUCN threat assessment undertaken recognized relative CWR threats using IUCN threat categories and the main threats limiting CWR maintenance. It also recognises the sources, severity, and nature of the threat. The more threatened taxa are given priority for preservation, as they may easily go to extinction. The knowledge of the threat to the CWR will help to prevent the threat and safeguard the taxa from further risk.

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Table 2S 1 Related crop and concept level of priority CWR for West Africa

S/N	FAMILY	GENUS	TAXON	RELATED CROP	COMMON CROP NAME	CONCEPT TYPE	CONCEPT LEVEL
1	Convolvulaceae	*Ipomoea*	*Ipomoea acanthocarpa* (Choisy) Hochst. ex Schweinf. & Asch.	*Ipomoea batatas* (L.) Lam.	Sweet potato	Taxon Group	4
2	Convolvulaceae	*Ipomoea*	*Ipomoea alba* L.	*Ipomoea batatas* (L.) Lam.	Sweet potato	Taxon Group	4
3	Convolvulaceae	*Ipomoea*	*Ipomoea aquatica* Forssk.	*Ipomoea batatas* (L.) Lam.	Sweet potato	Taxon Group	4
4	Convolvulaceae	*Ipomoea*	*Ipomoea argentaurata* Hallier f.	*Ipomoea batatas* (L.) Lam.	Sweet potato	Taxon Group	4
5	Convolvulaceae	*Ipomoea*	*Ipomoea asarifolia* (Desr.) Roem. & Schult.	*Ipomoea batatas* (L.) Lam.	Sweet potato	Taxon Group	4
6	Convolvulaceae	*Ipomoea*	*Ipomoea barteri* Baker	*Ipomoea batatas* (L.) Lam.	Sweet potato	Taxon Group	4
7	Convolvulaceae	*Ipomoea*	*Ipomoea blepharophylla* Hallier f.	*Ipomoea batatas* (L.) Lam.	Sweet potato	Taxon Group	4
8	Convolvulaceae	*Ipomoea*	*Ipomoea chrysochaetia* Hallier f.	*Ipomoea batatas* (L.) Lam.	Sweet potato	Taxon Group	4
9	Convolvulaceae	*Ipomoea*	*Ipomoea coptica* (L.) Roth ex Roem. & Schult.	*Ipomoea batatas* (L.) Lam.	Sweet potato	Taxon Group	4
10	Convolvulaceae	*Ipomoea*	*Ipomoea intrapilosa* Rose	*Ipomoea batatas* (L.) Lam.	Sweet potato	Taxon Group	4
11	Convolvulaceae	*Ipomoea*	*Ipomoea ochracea (Lindl.) Sweet*	*Ipomoea batatas* (L.) Lam.	Sweet potato	Taxon Group	4
12	Convolvulaceae	*Ipomoea*	*Ipomoea prismatosyphon* Welw.	*Ipomoea batatas* (L.) Lam.	Sweet potato	Taxon Group	4
13	Convolvulaceae	*Ipomoea*	*Ipomoea rubens* Choisy	*Ipomoea batatas* (L.) Lam.	Sweet potato	Taxon Group	4
14	Dioscoreaceae	*Dioscorea*	*Dioscorea abyssinica* Hochst. ex Kunth	*Dioscorea rotundata* Poir.	White yam	Gene Pool	2
15	Dioscoreaceae	*Dioscorea*	*Dioscorea baya* De Wild.	*Dioscorea rotundata* Poir.	White yam	Gene Pool	3
16	Dioscoreaceae	*Dioscorea*	*Dioscorea burkilliana* J.Miège	*Dioscorea rotundata* Poir.	White yam	Gene Pool	3
17	Dioscoreaceae	*Dioscorea*	*Dioscorea minutiflora* Engl.	*Dioscorea rotundata* Poir.	White yam	Gene Pool	2
18	Dioscoreaceae	*Dioscorea*	*Dioscorea praehensilis* Benth.	*Dioscorea rotundata* Poir.	White yam	Gene Pool	2
19	Dioscoreaceae	*Dioscorea*	*Dioscorea quartiniana* A.Rich.	*Dioscorea rotundata* Poir.	White yam	Taxon Group	4
20	Dioscoreaceae	*Dioscorea*	*Dioscorea sagittifolia* Pax	*Dioscorea rotundata* Poir.	White yam	Taxon Group	4
21	Dioscoreaceae	*Dioscorea*	*Dioscorea sagittifolia* var. *lecardii* (De Wild.) Nkounkou	*Dioscorea rotundata* Poir.	White yam	Gene Pool	2
22	Dioscoreaceae	*Dioscorea*	*Dioscorea sansibarensis* Pax	*Dioscorea rotundata* Poir.	White yam	Taxon Group	4
23	Dioscoreaceae	*Dioscorea*	*Dioscorea schimperiana* Hochst. ex Kunth	*Dioscorea rotundata* Poir.	White yam	Taxon Group	4

24	Dioscoreaceae	*Dioscorea*	*Dioscorea smilacifolia* De Wild. & T.Durand	*Dioscorea rotundata* Poir.	White yam	Gene Pool	2
25	Dioscoreaceae	*Dioscorea*	*Dioscorea togoensis* R.Knuth	*Dioscorea rotundata* Poir.	White yam	Gene Pool	2
26	Euphorbiaceae	*Manihot*	*Manihot esculenta* subsp. *peruviana* Crantz	*Manihot esculenta* Crantz	Cassava	Gene Pool	3
27	Malvaceae	*Gossypium*	*Gossypium anomalum* Wawra	*Gossypium hirsutum* Linn.	Upland cotton	Gene Pool	3
28	Malvaceae	*Gossypium*	*Gossypium barbadense* Linn.	*Gossypium hirsutum* Linn.	Upland cotton	Gene Pool	1B
29	Malvaceae	*Gossypium*	*Gossypium herbaceum* var. *acerifolium* (Guill. & Perr.) A. Chev.	*Gossypium hirsutum* Linn.	Upland cotton	Gene Pool	3
30	Papilionaceae	*Phaseolus*	*Phaseolus lunatus* Linn.	*Phaseolus vulgaris* Linn.	Common bean	Taxon Group	4
31	Papilionaceae	*Phaseolus*	*Phaseolus vulgaris* subsp. *abarigineus* L.	*Phaseolus vulgaris* Linn.	Common bean	Gene Pool	1B
32	Papilionaceae	*Vigna*	*Vigna ambacensis* Welw. ex Bak.	*Vigna unguiculata* (Linn.) Walp.	Cowpea	Taxon Group	4
33	Papilionaceae	*Vigna*	*Vigna desmodioides* Wilczek	*Vigna unguiculata* (Linn.) Walp.	Cowpea	Taxon Group	4
34	Papilionaceae	*Vigna*	*Vigna filicaulis* Hepper	*Vigna unguiculata* (Linn.) Walp.	Cowpea	Taxon Group	4
35	Papilionaceae	*Vigna*	*Vigna gracilis* (Guill. & Perr.) Hook. f.	*Vigna unguiculata* (Linn.) Walp.	Cowpea	Taxon Group	4
36	Papilionaceae	*Vigna*	*Vigna luteola* (Jacq.) Benth.	*Vigna unguiculata* (Linn.) Walp.	Cowpea	Taxon Group	4
37	Papilionaceae	*Vigna*	*Vigna macrorrhyncha* (Harms) Milne-Redhead	*Vigna unguiculata* (Linn.) Walp.	Cowpea	Taxon Group	4
38	Papilionaceae	*Vigna*	*Vigna marina* (Burm.) Merill	*Vigna unguiculata* (Linn.) Walp.	Cowpea	Taxon Group	4
39	Papilionaceae	*Vigna*	*Vigna multinervis* Hutch. & Dalz.	*Vigna unguiculata* (Linn.) Walp.	Cowpea	Taxon Group	4
40	Papilionaceae	*Vigna*	*Vigna nigritia* Hook. f.	*Vigna unguiculata* (Linn.) Walp.	Cowpea	Taxon Group	4
41	Papilionaceae	*Vigna*	*Vigna oblongifolia* A. Rich.	*Vigna unguiculata* (Linn.) Walp.	Cowpea	Taxon Group	4
42	Papilionaceae	*Vigna*	*Vigna racemosa* (G. Don) Hutch. & Dalz.	*Vigna unguiculata* (Linn.) Walp.	Cowpea	Taxon Group	4
43	Papilionaceae	*Vigna*	*Vigna reticulata* Hook. f.	*Vigna unguiculata* (Linn.) Walp.	Cowpea	Taxon Group	4
44	Poaceae	*Echinochloa*	*Echinochloa colonum* (L.) Link	*Echinochloa esculenta* (A. Braun) H. Scholz	Barnyard millet	Taxon Group	4
45	Poaceae	*Echinochloa*	*Echinochloa crus-galli* (L.) P.Beauv.	*Echinochloa esculenta* (A. Braun) H. Scholz	Barnyard millet	Gene Pool	1B
46	Poaceae	*Echinochloa*	*Echinochloa crus-pavonis* (Kunth) Schult	*Echinochloa esculenta* (A. Braun) H. Scholz	Barnyard millet	Taxon Group	4
47	Poaceae	*Echinochloa*	*Echinochloa frumentacea* Link	*Echinochloa esculenta* (A. Braun) H. Scholz	Barnyard millet	Gene Pool	2
48	Poaceae	*Echinochloa*	*Echinochloa pyramidalis* (Lam.) Hitchc. & Chase	*Echinochloa esculenta* (A. Braun) H. Scholz	Barnyard millet	Taxon Group	4
49	Poaceae	*Eleusine*	*Eleusine africana* Kenn. -O'Byrne	*Eleusine coracana* (L.) Gaertn.	Finger millet	Gene Pool	3

50	Poaceae	*Eleusine*	*Eleusine indica* (L.) Gaertn.	*Eleusine coracana* (L.) Gaertn.	Finger millet	Gene Pool	2
51	Poaceae	*Eragrostis*	*Eragrostis japonica* (Thunb.) Trin.	*Eragrostis tef* (Zuccagni) Trotter	Teff	Taxon Group	4
52	Poaceae	*Eragrostis*	*Eragrostis prolifera* (Sw.) Steud.	*Eragrostis tef* (Zuccagni) Trotter	Teff	Taxon Group	4
53	Poaceae	*Eragrostis*	*Eragrostis unioloides* (Retz.) Nees ex Steud.	*Eragrostis tef* (Zuccagni) Trotter	Teff	Taxon Group	4
54	Poaceae	*Hordeum*	*Hordeum bulbosum* L.	*Hordeum vulgare* L.	Barley	Gene Pool	2
55	Poaceae	*Oryza*	*Oryza barthii* A.Chev.	*Oryza sativa* L.	Rice	Gene Pool	1B
56	Poaceae	*Oryza*	*Oryza brachyantha* A.Chev. & Roehr.	*Oryza sativa* L.	Rice	Gene Pool	3
57	Poaceae	*Oryza*	*Oryza eichingeri* Peter	*Oryza sativa* L.	Rice	Gene Pool	2
58	Poaceae	*Oryza*	*Oryza glaberrima* Steud.	*Oryza sativa* L.	Rice	Gene Pool	1B
59	Poaceae	*Oryza*	*Oryza longistaminata* A.Chev. & Roehr.	*Oryza sativa* L.	Rice	Gene Pool	1B
60	Poaceae	*Oryza*	*Oryza punctata* Kotschy ex Steud.	*Oryza sativa* L.	Rice	Gene Pool	2
61	Poaceae	*Panicum*	*Panicum comorense* Mez	*Panicum miliaceum* L.	Proso millet	Taxon Group	4
62	Poaceae	*Panicum*	*Panicum repens* L.	*Panicum miliaceum* L.	Proso millet	Gene Pool	3
63	Poaceae	*Saccharum*	*Saccharum spontaneum* subsp. *spontaneum* L.	*Saccharum officinarum* L.	Sugarcane	Gene Pool	3
64	Poaceae	*Saccharum*	*Saccharum spontaneum* subsp. *aegyptiacum* (Willd.) Hack.	*Saccharum officinarum* L.	Sugarcane	Gene Pool	2
65	Poaceae	*Sorghum*	*Sorghum purpureosericeum* (Hochst. ex A.Rich.) Schweinf. & Asch	*Sorghum bicolor* (L.) Moench	Sorghum	Gene Pool	3
66	Poaceae	*Sorghum*	*Sorghum virgatum* (Hack.) Stapf	*Sorghum bicolor* (L.) Moench	Sorghum	Taxon Group	4
67	Sterculiaceae	*Cola*	*Cola acuminata* (P. Beauv.) Schott & Endl.	*Cola nitida* (Vent.) Schott & Endl.	Kola nut	Gene Pool	1B
68	Sterculiaceae	*Cola*	*Cola altissima* Engl.	*Cola nitida* (Vent.) Schott & Endl.	Kola nut	Taxon Group	4
69	Sterculiaceae	*Cola*	*Cola angustifolia* K. Schum.	*Cola nitida* (Vent.) Schott & Endl.	Kola nut	Taxon Group	4
70	Sterculiaceae	*Cola*	*Cola argentea* Mast.	*Cola nitida* (Vent.) Schott & Endl.	Kola nut	Taxon Group	4
71	Sterculiaceae	*Cola*	*Cola attiensis* Aubrév. & Pellegr.	*Cola nitida* (Vent.) Schott & Endl.	Kola nut	Taxon Group	4
72	Arecaceae	*Phoenix*	*Phoenix reclinata* Jacq.	*Phoenix dactylifera* L.	Date palm	Gene Pool	1B
73	Dioscoreaceae	*Dioscorea*	*Dioscorea alata* L.	*Dioscorea rotundata* Poir.	White yam	Gene Pool	2
74	Dioscoreaceae	*Dioscorea*	*Dioscorea bulbifera* L.	*Dioscorea rotundata* Poir.	White yam	Gene Pool	2
75	Dioscoreaceae	*Dioscorea*	*Dioscorea cayenensis* Lam.	*Dioscorea rotundata* Poir.	White yam	Gene Pool	1B
76	Euphorbiaceae	*Manihot*	*Manihot carthagenensis* (Jacq.) Müll.Arg.	*Manihot esculenta* Crantz	cassava	Gene Pool	2

77	Euphorbiaceae	*Manihot*	*Manihot carthagenensis* subsp. *glaziovii* (Müll.Arg.) Allem	*Manihot esculenta* Crantz	cassava	Gene Pool	2
78	Euphorbiaceae	*Manihot*	*Manihot dichotoma* Ule	*Manihot esculenta* Crantz	cassava	Gene Pool	2
79	Euphorbiaceae	*Manihot*	*Manihot esculenta* subsp. *flabellifolia* Crantz	*Manihot esculenta* Crantz	cassava	Gene Pool	1B
80	Papilionaceae	*Phaseolus*	*Phaseolus vulgaris* var *aborigines* L.	*Phaseolus vulgaris* Linn.	Common bean	Gene Pool	1B
81	Papilionaceae	*Vigna*	*Vigna unguiculata* subsp. *aduensis* (L.) Walp.	*Vigna unguiculata* (Linn.) Walp.	Cowpea	Gene Pool	2
82	Papilionaceae	*Vigna*	*Vigna unguiculata* subsp. *alba* (L.) Walp.	*Vigna unguiculata* (Linn.) Walp.	Cowpea	Gene Pool	2
83	Papilionaceae	*Vigna*	*Vigna unguiculata* subsp. *baoulensis* (L.) Walp.	*Vigna unguiculata* (Linn.) Walp.	Cowpea	Gene Pool	2
84	Papilionaceae	*Vigna*	*Vigna unguiculata* subsp. *burundiensis* (L.) Walp.	*Vigna unguiculata* (Linn.) Walp.	Cowpea	Gene Pool	2
85	Papilionaceae	*Vigna*	*Vigna unguiculata* subsp. *dekindtiana* (L.) Walp.	*Vigna unguiculata* (Linn.) Walp.	Cowpea	Gene Pool	1B
86	Papilionaceae	*Vigna*	*Vigna unguiculata* subsp. *letouzeyi*(L.) Walp.	*Vigna unguiculata* (Linn.) Walp.	Cowpea	Gene Pool	2
87	Papilionaceae	*Vigna*	*Vigna unguiculata* subsp. *pawekiae* (L.) Walp.	*Vigna unguiculata* (Linn.) Walp.	Cowpea	Gene Pool	2
88	Papilionaceae	*Vigna*	*Vigna unguiculata* subsp. *pubescens* (L.) Walp.	*Vigna unguiculata* (Linn.) Walp.	Cowpea	Gene Pool	2
89	Papilionaceae	*Vigna*	*Vigna unguiculata* subsp. *stenophylla* (L.) Walp.	*Vigna unguiculata* (Linn.) Walp.	Cowpea	Gene Pool	1B
90	Papilionaceae	*Vigna*	*Vigna unguiculata* subsp. *tenuis* (L.) Walp.	*Vigna unguiculata* (Linn.) Walp.	Cowpea	Gene Pool	1B
91	Papilionaceae	*Vigna*	*Vigna unguiculata* subsp. *Unguiculata* var. *spontanea* (L.) Walp.	*Vigna unguiculata* (Linn.) Walp.	Cowpea	Gene Pool	1B
92	Poaceae	*Digitaria*	*Digitaria barbinodis* Henrard	*Digitaria exilis* (Kippist) Stapf	Fonio	Gene Pool	3
93	Poaceae	*Digitaria*	*Digitaria ciliaris* (Retz.) Koeler	*Digitaria exilis* (Kippist) Stapf	Fonio	Gene Pool	2
94	Poaceae	*Digitaria*	*Digitaria fuscescens* (J.Presl) Henrard	*Digitaria exilis* (Kippist) Stapf	Fonio	Gene Pool	2
95	Poaceae	*Digitaria*	*Digitaria iburua* Stapf	*Digitaria exilis* (Kippist) Stapf	Fonio	Gene Pool	2
96	Poaceae	*Eleusine*	*Eleusine coracana* subsp. *coracana* (L.) Gaertn.	*Eleusine coracana* (L.) Gaertn.	Finger millet	Gene Pool	1B
97	Poaceae	*Eragrostis*	*Eragrostis pilosa* (L.) P.Beauv.	*Eragrostis tef* (Zuccagni) Trotter	Teff	Gene Pool	1B
98	Poaceae	*Hordeum*	*Hordeum vulgare* subsp. *spontaneum* L.	*Hordeum vulgare* L.	Barley	Gene Pool	1B
99	Poaceae	*Sorghum*	*Sorghum bicolor* subsp. *verticilliflorum* (L.) Moench	*Sorghum bicolor* (L.) Moench	Sorghum	Gene Pool	1B
100	Poaceae	*Sorghum*	*Sorghum drummondii* (Nees ex Steud.) Millsp. & Chase	*Sorghum bicolor* (L.) Moench	Sorghum	Gene Pool	2
101	Poaceae	*Triticum*	*Triticum turgidum* L.	*Triticum aestivum* L.	Wheat	Gene Pool	1B
102	Poaceae	*Triticum*	*Triticum turgidum* subsp. *durum* (Desf.) Husn.	*Triticum aestivum* L.	Wheat	Gene Pool	1B

Table 2S 2 Endemicity and International Union for Conservation of Nature and Natural Resources (IUCN) category of priority CWR

S/N	TAXON	COMMON CROP NAME	DISTRIBUTION	DISTRIBUTION STATUS	ASSESSMENT LEVEL	IUCN CATEGORY
1	*Ipomoea acanthocarpa* (Choisy) Hochst. ex Schweinf. & Asch.	Sweet potato	Niger, Nigeria, Senegal	Regional Endemic	Global	Least Concern
2	*Ipomoea alba* L.	Sweet potato	Ghana, Guinea, Côte D'Ivoire, Liberia, Nigeria, Sierra Leone, Togo	Regional Endemic	Global	Least Concern
3	*Ipomoea aquatica* Forssk.	Sweet potato	Gambia, Ghana, Guinea, Côte D'Ivoire, Liberia, Mali, Mauritania, Nigeria, Senegal, Sierra Leone, Togo	Regional Endemic	Global	Least Concern
4	*Ipomoea argentaurata* Hallier f.	Sweet potato	Ghana, Guinea, Côte D'Ivoire, Nigeria, Sierra Leone, Togo	Regional Endemic	Global	Least Concern
5	*Ipomoea asarifolia* (Desr.) Roem. & Schult.	Sweet potato	Gambia, Ghana, Guinea, Côte D'Ivoire, Mali, Mauritania, Niger, Nigeria, Senegal	Regional Endemic	Global	Least Concern
6	*Ipomoea barteri* Baker	Sweet potato	Guinea, Côte D'Ivoire, Mali, Nigeria, Senegal, Sierra Leone	Regional Endemic	Global	Least Concern
7	*Ipomoea blepharophylla* Hallier f.	Sweet potato	Benin, Ghana, Guinea, Côte D'Ivoire, Mali, Nigeria, Senegal	Regional Endemic	Global	Least Concern
8	*Ipomoea chrysochaetia* Hallier f.	Sweet potato	Guinea, Côte D'Ivoire, Nigeria, Senegal, Sierra Leone	Regional Endemic	Global	Least Concern
9	*Ipomoea coptica* (L.) Roth ex Roem. & Schult.	Sweet potato	Ghana, Guinea, Mali, Mauritania, Nigeria, Niger, Senegal, Togo	Regional Endemic	Global	Least Concern
10	*Ipomoea intrapilosa* Rose	Swee tpotato	Nigeria	National Endemic	Global	Least Concern
11	*Ipomoea ochracea (Lindl.) Sweet*	Sweet potato	Ghana, Guinea-Bissau, Guinea, Côte D'Ivoire, Mauritania, Nigeria, Senegal, Sierra Leone, Togo	Regional Endemic	Global	Least Concern
12	*Ipomoea prismatosyphon* Welw.	Sweet potato	Nigeria	National Endemic	Global	Least Concern
13	*Ipomoea rubens* Choisy	Sweet potato	Benin, Ghana, Guinea, Côte D'Ivoire, Mauritania, Niger, Nigeria, Senegal	Regional Endemic	Global	Least Concern
14	*Dioscorea abyssinica* Hochst. ex Kunth	White yam	Benin, Burkina Faso, Ghana, Côte D'Ivoire, Liberia, Mali, Nigeria, Senegal	Regional Endemic	Global	Least Concern
15	*Dioscorea baya* De Wild.	White yam	Côte D'Ivoire, Liberia	Regional Endemic	Global	Least Concern
16	*Dioscorea burkilliana* J.Miège	White yam	Benin, Côte D'Ivoire, Liberia, Sierra Leone	Regional Endemic	Global	Least Concern
17	*Dioscorea minutiflora* Engl.	White yam	Benin, Burkina Faso, Guinea, Côte D'Ivoire, Liberia, Nigeria, Senegal, Sierra Leone, Togo	Regional Endemic	Global	Least Concern
18	*Dioscorea praehensilis* Benth.	White yam	Benin, Burkina Faso, Gambia, Ghana, Guinea, Guinea-Bissau, Côte D'Ivoire, Liberia, Nigeria, Sierra Leone, Togo	Regional Endemic	Global	Least Concern
19	*Dioscorea quartiniana* A.Rich.	White yam	Benin, Burkina Faso, Gambia, Ghana, Guinea-Bissau, Côte D'Ivoire, Liberia, Nigeria, Senegal, Sierra Leone	Regional Endemic	Global	Least Concern
20	*Dioscorea sagittifolia* Pax	White yam	Benin, Burkina Faso, Gambia, Guinea, Guinea-Bissau, Côte D'Ivoire, Liberia, Nigeria, Senegal, Sierra Leone, Togo	Regional Endemic	Global	Least Concern

21	*Dioscorea sagittifolia* var. *lecardii* (De Wild.) Nkounkou	White yam	Benin, Gambia, Guinea, Guinea-Bissau, Côte D'Ivoire, Liberia, Mali, Senegal, Sierra Leone, Togo	Regional Endemic	Global	Least Concern
22	*Dioscorea sansibarensis* Pax	White yam	Benin, Guinea, Côte D'Ivoire, Nigeria, Togo	Regional Endemic	Global	Near Threatened
23	*Dioscorea schimperiana* Hochst. ex Kunth	White yam	Burkina Faso, Nigeria	Regional Endemic	Global	Least Concern
24	*Dioscorea smilacifolia* De Wild. & T.Durand	White yam	Benin, Burkina Faso, Ghana, Guinea, Côte D'Ivoire, Liberia, Nigeria, Sierra Leone, Togo	Regional Endemic	Global	Least Concern
25	*Dioscorea togoensis* R.Knuth	White yam	Benin, Burkina Faso, Gambia, Ghana, Guinea, Côte D'Ivoire, Liberia, Nigeria, Senegal, Sierra Leone, Togo	Regional Endemic	Global	Least Concern
26	*Manihot esculenta* subsp. *peruviana* Crantz	cassava	Unknown	Unknown	Global	Least Concern
27	*Gossypium anomalum* Wawra	Upland cotton	Mali, Niger	Regional Endemic	Global	Near Threatened
28	*Gossypium barbadense* Linn.	Upland cotton	Ghana, Liberia, Nigeria, Senegal, Sierra Leone, Togo	Regional Endemic	Global	Least Concern
29	*Gossypium herbaceum* var. *acerifolium* (Guill. & Perr.) A. Chev.	Upland cotton	Benin, Senegal, Nigeria	Regional Endemic	Global	Data Deficient
30	*Phaseolus lunatus* Linn.	Common bean	Benin, Côte D'Ivoire, Liberia, Nigeria, Senegal, Sierra Leone, Togo	Regional Endemic	Global	Least Concern
31	*Phaseolus vulgaris* subsp. *abarigineus* L.	Common bean	Unknown	Unknown	Global	Least Concern
32	*Vigna ambacensis* Welw. ex Bak.	Cowpea	Nigeria	National Endemic	Global	Least Concern
33	*Vigna desmodioides* Wilczek	Cowpea	Sierra Leone, Nigeria	Regional Endemic	Global	Endangered
34	*Vigna filicaulis* Hepper	Cowpea	Ghana, Côte D'Ivoire	Regional Endemic	Global	Least Concern
35	*Vigna gracilis* (Guill. & Perr.) Hook. f.	Cowpea	Gambia, Guinea-Bissau, Mali, Liberia, Nigeria, Senegal, Sierra Leone	Regional Endemic	Global	Least Concern
36	*Vigna luteola* (Jacq.) Benth.	Cowpea	Benin, Ghana, Liberia, Senegal, Sierra Leone, Togo	Regional Endemic	Global	Least Concern
37	*Vigna macrorrhyncha* (Harms) Milne-Redhead	Cowpea	Nigeria	National Endemic	Global	Least Concern
38	*Vigna marina* (Burm.) Merill	Cowpea	Liberia, Nigeria	Regional Endemic	Global	Least Concern
39	*Vigna multinervis* Hutch. & Dalz.	Cowpea	Nigeria, Togo	Regional Endemic	Global	Least Concern
40	*Vigna nigritia* Hook. f.	Cowpea	Ghana, Côte D'Ivoire, Nigeria, Sierra Leone	Regional Endemic	Global	Least Concern
41	*Vigna oblongifolia* A. Rich.	Cowpea	Unknown	Unknown	Global	Least Concern
42	*Vigna racemosa* (G. Don) Hutch. & Dalz.	Cowpea	Ghana, Gambia, Guinea-Bissau, Mali, Nigeria, Senegal, Togo	Regional Endemic	Global	Least Concern

43	*Vigna reticulata* Hook. f.	Cowpea	Ghana, Nigeria, Senegal, Sierra Leone, Togo	Regional Endemic	Global	Least Concern
44	*Echinochloa colonum* (L.) Link	Barnyard millet	Benin, Burkina Faso, Côte D'Ivoire, Gambia, Ghana, Guinea, Guinea-Bissau, Mali, Mauritania, Liberia, Niger, Nigeria, Senegal, Sierra Leone, Togo	Regional Endemic	Global	Least Concern
45	*Echinochloa crus-galli* (L.) P.Beauv.	Barnyard millet	Burkina Faso, Côte D'Ivoire, Togo	Regional Endemic	Global	Least Concern
46	*Echinochloa crus-pavonis* (Kunth) Schult	Barnyard millet	Benin, Ghana, Guinea, Guinea-Bissau, Côte D'Ivoire, Liberia, Niger, Nigeria, Sierra Leone, Togo	Regional Endemic	Global	Least Concern
47	*Echinochloa frumentacea* Link	Barnyard millet	Gambia, Nigeria, Togo	Regional Endemic	Global	Least Concern
48	*Echinochloa pyramidalis* (Lam.) Hitchc. & Chase	Barnyard millet	Benin, Burkina Faso, Côte D'Ivoire, Gambia, Ghana, Guinea, Guinea-Bissau, Mali, Mauritania, Niger, Nigeria, Senegal, Sierra Leone, Togo	Regional Endemic	Global	Least Concern
49	*Eleusine africana* Kenn. -O'Byrne	Finger millet	Benin, Burkina Faso, Gambia, Ghana, Guinea, Guinea-Bissau, Mali, Niger, Nigeria, Senegal, Sierra Leone, Togo	Regional Endemic	Global	Least Concern
50	*Eleusine indica* (L.) Gaertn.	Finger millet	Benin, Burkina Faso, Côte D'Ivoire; Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Mauritania, Niger, Nigeria, Senegal, Sierra Leone, Togo.	Regional Endemic	Global	Least Concern
51	*Eragrostis japonica* (Thunb.) Trin.	Teff	Benin, Burkina Faso, Côte D'Ivoire; Gambia, Ghana, Guinea, Guinea-Bissau, Mali, Mauritania, Niger, Nigeria, Senegal, Sierra Leone, Togo.	Regional Endemic	Global	Least Concern
52	*Eragrostis prolifera* (Sw.) Steud.	Teff	Benin, Burkina Faso, Côte D'Ivoire, Gambia, Ghana, Mali, Mauritania, Niger, Nigeria, Senegal, Togo.	Regional Endemic	Global	Least Concern
53	*Eragrostis unioloides* (Retz.) Nees ex Steud.	Teff	Guinea, Liberia, Sierra Leone	Regional Endemic	Global	Least Concern
54	*Hordeum bulbosum* L.	Barley	Mauritania	National Endemic	Global	Least Concern
55	*Oryza barthii* A.Chev.	Rice	Benin, Burkina Faso, Côte D'Ivoire, Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Mauritania, Niger, Nigeria, Senegal, Sierra Leone, Togo.	Regional Endemic	Global	Least Concern
56	*Oryza brachyantha* A.Chev. & Roehr.	Rice	Côte D'Ivoire, Guinea, Guinea-Bissau, Mali, Mauritania, Niger, Nigeria, Senegal, Sierra Leone	Regional Endemic	Global	Data Deficient
57	*Oryza eichingeri* Peter	Rice	Côte D'Ivoire	National Endemic	Global	Least Concern
58	*Oryza glaberrima* Steud.	Rice	Benin, Burkina Faso, Côte D'Ivoire, Gambia, Guinea, Guinea-Bissau, Mali, Mauritania, Niger, Senegal, Sierra Leone, Togo.	Regional Endemic	Global	Least Concern
59	*Oryza longistaminata* A.Chev. & Roehr.	Rice	Benin, Burkina Faso, Côte D'Ivoire, Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Niger, Nigeria, Senegal, Sierra Leone, Togo.	Regional Endemic	Global	Least Concern
60	*Oryza punctata* Kotschy ex Steud.	Rice	Benin, Ghana, Côte D'Ivoire, Nigeria, Togo	Regional Endemic	Global	Least Concern
61	*Panicum comorense* Mez	Proso millet	Ghana, Nigeria, Togo	Regional Endemic	Global	Least Concern
62	*Panicum repens* L.	Proso millet	Benin, Côte D'Ivoire, Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Mauritania, Niger, Nigeria, Senegal, Sierra Leone, Togo	Regional Endemic	Global	Least Concern
63	*Saccharum spontaneum* subsp. *spontaneum* L.	Sugarcane	Unknown	Unknown	Global	Least Concern

64	*Saccharum spontaneum* subsp. *aegyptiacum* (Willd.) Hack.	Sugarcane	Burkina Faso, Ghana, Nigeria, Niger, Togo	Regional Endemic	Global	Least Concern
65	*Sorghum purpureosericeum* (Hochst. ex A.Rich.) Schweinf. & Asch	Sorghum	Burkina Faso, Mali, Nigeria	Regional Endemic	Global	Least Concern
66	*Sorghum virgatum* (Hack.) Stapf	Sorghum	Mali, Mauritania, Niger, Senegal	Regional Endemic	Global	Least Concern
67	*Cola acuminata* (P. Beauv.) Schott & Endl.	Kola nut	Benin, Côte D'Ivoire, Liberia, Nigeria, Sierra Leone, Togo	Regional Endemic	Global	Least Concern
68	*Cola altissima* Engl.	Kola nut	Nigeria	National Endemic	Global	Least Concern
69	*Cola angustifolia* K. Schum.	Kola nut	Sierra Leone	National Endemic	Global	Least Concern
70	*Cola argentea* Mast.	Kola nut	Nigeria	National Endemic	Global	Least Concern
71	*Cola attiensis* Aubrév. & Pellegr.	Kola nut	Côte D'Ivoire	National Endemic	Global	Least Concern
72	*Phoenix reclinata* Jacq.	Date palm	Benin, Burkina Faso, Gambia, Ghana, Guinea-Bissau, Guinea, Côte D'Ivoire, Liberia, Nigeria, Senegal, Sierra Leone, Togo	Regional Endemic	Not applicable	Not Evaluated
73	*Dioscorea alata* L.	White yam	Benin, Burkina Faso, Guinea-Bissau, Mali, Senegal, Togo	Regional Endemic	Not applicable	Not Evaluated
74	*Dioscorea bulbifera* L.	White yam	Benin, Burkina Faso, Ghana, Guinea-Bissau, Guinea, Côte D'Ivoire, Liberia, Mali, Nigeria, Senegal, Sierra Leone, Togo	Regional Endemic	Not applicable	Not Evaluated
75	*Dioscorea cayenensis* Lam.	White yam	Benin, Burkina Faso, Gambia, Ghana, Guinea-Bissau, Guinea, Côte D'Ivoire, Liberia, Mali, Niger, Nigeria, Senegal, Sierra Leone, Togo	Regional Endemic	Not applicable	Not Evaluated
76	*Manihot carthagenensis* (Jacq.) Müll.Arg.	cassava	Benin, Burkina Faso, Gambia, Togo	Regional Endemic	Not applicable	Not Evaluated
77	*Manihot carthagenensis* subsp. *glaziovii* (Müll.Arg.) Allem	cassava	Benin, Burkina Faso, Gambia, Togo	Regional Endemic	Not applicable	Not Evaluated
78	*Manihot dichotoma* Ule	cassava	Unknown	Unknown	Not applicable	Not Evaluated
79	*Manihot esculenta* subsp. *flabellifolia* Crantz	cassava	Unknown	Unknown	Not applicable	Not Evaluated
80	*Phaseolus vulgaris* var *aborigineus*L.	Common bean	unknown	Unknown	Not applicable	Not Evaluated
81	*Vigna unguiculata* subsp. *aduensis*(L.) Walp.	Cowpea	unknown	unknown	Not applicable	Not Evaluated
82	*Vigna unguiculata* subsp. *alba* (L.) Walp.	Cowpea	unknown	unknown	Not applicable	Not Evaluated
83	*Vigna unguiculata* subsp. *baoulensis*(L.) Walp.	Cowpea	Benin, Cote D'Ivoire, Ghana, Liberia, Nigeria, Sierra Leone, Togo	Regional Endemic	Not applicable	Not Evaluated
84	*Vigna unguiculata* subsp. *burundiensis*(L.) Walp.	Cowpea	Unknown	Unknown	Not applicable	Not Evaluated
85	*Vigna unguiculata* subsp. *dekindtiana*(L.) Walp.	Cowpea	Unknown	Unknown	Not applicable	Not Evaluated

86	*Vigna unguiculata* subsp. *letouzeyi*(L.) Walp.	Cowpea	Unknown	Unknown	Not applicable	Not Evaluated
87	*Vigna unguiculata* subsp. *pawekiae*(L.) Walp.	Cowpea	Unknown	Unknown	Not applicable	Not Evaluated
88	*Vigna unguiculata* subsp. *pubescens*(L.) Walp.	Cowpea	Unknown	Unknown	Not applicable	Not Evaluated
89	*Vigna unguiculata* subsp. *stenophylla* (L.) Walp.	Cowpea	Unknown	Unknown	Not applicable	Not Evaluated
90	*Vigna unguiculata* subsp. *tenuis* (L.) Walp.	Cowpea	Unknown	Unknown	Not applicable	Not Evaluated
91	*Vigna unguiculata* subsp. *Unguiculata* var. *spontanea* (L.) Walp.	Cowpea	Unknown	Unknown	Not applicable	Not Evaluated
92	*Digitaria barbinodis* Henrard	Fonio	Mali, Nigeria	Regional Endemic	Not applicable	Not Evaluated
93	*Digitaria ciliaris* (Retz.) Koeler	Fonio	Benin, Burkina Faso, Gambia, Ghana, Côte D'Ivoire, Guinea, Guinea-Bissau, Liberia, Mali, Mauritania, Niger, Nigeria, Senegal, Sierra Leone	Regional Endemic	Not applicable	Not Evaluated
94	*Digitaria fuscescens* (J.Presl) Henrard	Fonio	Ghana, Côte D'Ivoire, Liberia, Niger, Nigeria	Regional Endemic	Not applicable	Not Evaluated
95	*Digitaria iburua* Stapf	Fonio	Benin, Côte D'Ivoire, Nigeria, Niger, Togo	Regional Endemic	Not applicable	Not Evaluated
96	*Eleusine coracana* subsp. *coracana* (L.) Gaertn.	Finger millet	Unknown	Unknown	Not applicable	Not Evaluated
97	*Eragrostis pilosa* (L.) P.Beauv.	Teff	Benin, Burkina Faso, Côte D'Ivoire, Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Mauritania, Niger, Nigeria, Senegal, Sierra Leone, Togo	Regional Endemic	Not applicable	Not Evaluated
98	*Hordeum vulgare* subsp. *spontaneum* L.	Barley	Unknown	Unknown	Not applicable	Not Evaluated
99	*Sorghum bicolor* subsp. *verticilliflorum* (L.) Moench	Sorghum	Unknown	Unknown	Not applicable	Not Evaluated
100	*Sorghum drummondii* (Nees ex Steud.) Millsp. & Chase	Sorghum	Mali, Niger	Regional Endemic	Not applicable	Not Evaluated
101	*Triticum turgidum* L.	Wheat	Unknown	Unknown	Not applicable	Not Evaluated
102	*Triticum turgidum* subsp. *durum* (Desf.) Husn.	Wheat	Unknown	Unknown	Not applicable	Not Evaluated

Table 3S1: Number of priority CWR in the network of protected areas in West Africa

No	Protected area	Country	Designation	IUCN Category	Total number of present point	Number of priority CWRs
1	Agoua	Benin	Classified Forest	Not Reported	4	2

2	Agrimey	Benin	Classified Forest	Not Reported	3	2
3	Aïr and Ténéré Natural Reserves	Niger	Nature Reserve	IV	5	4
4	Alawa	Nigeria	Game Reserve	Not Reported	6	2
5	Alédjo	Togo	Faunal Reserve	IV	1	1
6	Amakpave	Togo	Forest Reserve	Not Reported	2	1
7	Anguededou	Cote d' Ivoire	Classified Forest	Not Reported	1	1
8	Ansongo Giraffe Reserve	Mali	Partial Wildlife Reserve	IV	1	1
9	Apepesu River	Ghana	Forest Reserve	IV	3	1
10	Atakora	Benin	Hunting Zone	VI	16	4
11	Atchérigbé	Benin	Classified Forest	Not Reported	2	2
12	Atilakoutse	Togo	Forest Reserve	Not Reported	3	1
13	Auya	Nigeria	Forest Reserve	Not Reported	1	1
14	Azagny National Park	Cote d' Ivoire	National Park	II	4	3
15	Badiar	Guinea	National Park	II	18	6
16	Badonou	Cote d' Ivoire	Classified Forest	Not Reported	8	1
17	Bam Ngelzarma	Nigeria	Forest Reserve	Not Reported	1	1
18	Banco National Park	Cote d' Ivoire	National Park	II	17	5
19	Bansie	Burkina Faso	Classified Forest	Not Reported	1	1
20	Baobolong	Gambia	Wetland Reserve	VI	19	1
21	Baoule	Togo	Forest Reserve	Not Reported	1	1
22	Barawa	Nigeria	Forest Reserve	Not Reported	13	1
23	Barrage de Ouagadougou	Burkina Faso	Classified Forest	Not Reported	1	1
24	Bassari-Montagne	Togo	Forest Reserve	Not Reported	2	1
25	Besso	Cote d' Ivoire	Classified Forest	Not Reported	1	1
26	Bia National Park	Ghana	National Park	II	8	2
27	Biliri Hills	Nigeria	Forest Reserve	Not Reported	1	1
28	Bissiga	Burkina Faso	Classified Forest	Not Reported	7	4
29	Borgu	Nigeria	Forest Reserve	Not Reported	8	3

30	Boucle de la Pendjari	Benin	National Park	II	65	16
31	Bui	Ghana	National Park	II	1	1
32	Central Shendam	Nigeria	Forest Reserve	Not Reported	1	1
33	Cliff of Bandiagara (Land of the Dogons)	Mali	World Heritage Site (natural or mixed)	Not Applicable	40	10
34	Comoe National Park	Cote d' Ivoire	UNESCO-MAB Biosphere Reserve	Not Applicable	407	24
35	Counsignaki	Guinea	Classified Forest	Not Reported	2	1
36	Cross River	Nigeria	National Park	II	7	5
37	Dagida	Nigeria	Game Reserve	IV	3	1
38	Dan	Burkina Faso	Classified Forest	Not Reported	4	1
39	Dankaiwa	Nigeria	Forest Reserve	Not Reported	3	1
40	Delta du Saloum	Senegal	National Park	II	2	1
41	Diécké	Guinea	Classified Forest	Not Reported	2	2
42	Digya	Ghana	National Park	II	4	4
43	Dinderesso	Burkina Faso	Classified Forest	Not Reported	1	1
44	Djamde	Togo	Faunal Reserve	IV	2	2
45	Djigbé	Benin	Classified Forest	Not Reported	1	1
46	Djona	Benin	Hunting Zone	VI	58	7
47	Djoudj National Bird Sanctuary	Senegal	World Heritage Site (natural or mixed)	Not Reported	7	3
48	Dogo	Benin	Classified Forest	Not Reported	45	10
49	Doro	Nigeria	Forest Reserve	Not Reported	2	1
50	Dosso	Niger	Partial Fauna Reserve	IV	48	13
51	Dulombi	Guinea - Bissau	National Park	Not Reported	12	4
52	East Nimba Nature Reserve	Liberia	Nature Reserve	Not Reported	6	5
53	Ekenwan	Nigeria	Forest Reserve	Not Reported	1	1
54	Eto	Togo	Forest Reserve	Not Reported	2	1
55	Farangbaia	Sierra Leone	Forest Reserve	Not Reported	1	1
56	Fazao-Malfakassa	Togo	National Park	II	3	3
57	Ferlo-Nord	Senegal	Wildlife Reserve	IV	16	6

58	Ferlo-Sud	Senegal	Wildlife Reserve	IV	51	12
59	Gambaga Scarp East	Ghana	Forest Reserve	III	3	3
60	Gambari	Nigeria	Forest Reserve	Not Reported	8	6
61	Gashaka-Gumti	Nigeria	National Park	II	2	1
62	Gazabure	Nigeria	Forest Reserve	Not Reported	2	2
63	Gbele	Ghana	Resource Reserve	VI	2	2
64	Gitata	Nigeria	Forest Reserve	Not Reported	1	1
65	Gonse	Burkina Faso	Classified Forest	Not Reported	8	4
66	Goudi	Cote d' Ivoire	Classified Forest	Not Reported	1	1
67	Gougoun	Benin	Classified Forest	Not Reported	23	9
68	Gourma Elephant Reserve	Mali	Partial Wildlife Reserve	IV	17	8
69	Grebo National Forest Park	Liberia	National Forest Park	Not Reported	2	1
70	Ibadan	Nigeria	Forest Reserve	Not Reported	1	1
71	Idanre	Nigeria	Forest Reserve	Not Reported	1	1
72	Iggi River	Nigeria	Forest Reserve	Not Reported	2	2
73	Ilaro	Nigeria	Forest Reserve	Not Reported	3	3
74	Iles Ehotile National Park	Cote d' Ivoire	National Park	II	2	2
75	Illoka'oje	Nigeria	Forest Reserve	Not Reported	1	1
76	Iwa River	Nigeria	Forest Reserve	Not Reported	1	1
77	Kabore-Tambi	Burkina Faso	National Park	II	2	2
78	Kafnikoro	Nigeria	Forest Reserve	Not Reported	4	2
79	Kainji Lake	Nigeria	National Park	II	10	4
80	Kalakpa	Ghana	Resource Reserve	VI	5	5
81	Kéniébaoulé	Mali	Total Wildlife Reserve	IV	1	1
82	Kétou	Benin	Classified Forest	Not Reported	21	6
83	Koflande	Burkina Faso	Classified Forest	Not Reported	2	2
84	Kpashimi	Nigeria	Forest Reserve	Not Reported	1	1
85	Kuru Hills	Sierra Leone	National Park	Not Reported	1	1

86	La Lama Nord	Benin	Classified Forest	Not Reported	157	16
87	La Lama-Sud	Benin	Classified Forest	Not Reported	11	6
88	La Sota	Benin	Classified Forest	Not Reported	8	2
89	Lagoa de Cufada	Guinea - Bissau	Ramsar Site, Wetland of International Importance	Not Reported	38	9
90	L'Alibori Supérieur	Benin	Classified Forest	Not Reported	4	3
91	Lili	Togo	Forest Reserve	Not Reported	15	7
92	Logozohé	Benin	Classified Forest	Not Reported	1	1
93	Loma Mountains	Sierra Leone	National Park	Not Reported	42	10
94	Mabi/Yaya	Cote d' Ivoire	Classified Forest	Not Reported	1	1
95	Mando Road South	Nigeria	Forest Reserve	Not Reported	2	2
96	Marago River	Ghana	Forest Reserve	VI	2	2
97	Marahoue National Park	Cote d' Ivoire	National Park	II	5	5
98	Massif du Ziama	Guinea	Classified Forest	Not Reported	6	3
99	Mayo Ndaga	Nigeria	Forest Reserve	Not Reported	2	1
100	Minna	Nigeria	Forest Reserve	Not Reported	1	1
101	Mole	Ghana	National Park	II	26	11
102	Monogaga	Cote d' Ivoire	Classified Forest	Not Reported	1	1
103	Mont Sangbe National Park	Cote d' Ivoire	National Park	II	2	1
104	Monts Kouffé	Benin	Classified Forest	Not Reported	250	16
105	Monts Nimba	Guinea	Strict Nature Reserve	Ia	63	11
106	Mopri	Cote d' Ivoire	Classified Forest	Not Reported	1	1
107	Mount Nimba Integral Reserve	Cote d' Ivoire	Integral nature reserve	Ia	3	2
108	Mt. Yonon	Guinea	Classified Forest	Not Reported	3	2
109	Nasarawa	Nigeria	Forest Reserve	Not Reported	1	1
110	N'Dama	Guinea	Classified Forest	Not Reported	2	2
111	Ndiael	Senegal	Wildlife Reserve	IV	2	1
112	Niangoloko	Burkina Faso	Classified Forest	Not Reported	4	1

113	Nimba West	Liberia	National Park	Not Reported	2	2
114	Niokolo Koba National Park	Senegal	World Heritage Site (natural or mixed)	Not Applicable	252	21
115	Oban Group	Nigeria	Forest Reserve	Not Reported	1	1
116	Obaretin	Nigeria	Forest Reserve	Not Reported	1	1
117	Ohumbe	Nigeria	Forest Reserve	Not Reported	2	2
118	Oiseaux du Djoudj	Senegal	National Park	II	5	3
119	Okomu	Nigeria	Wildlife Sanctuary	Not Reported	4	1
120	Old Oyo	Nigeria	National Park	II	5	5
121	Olokemeji	Nigeria	Forest Reserve	Not Reported	5	3
122	Omo	Nigeria	Forest Reserve	Not Reported	3	2
123	Oti-Kéran	Togo	National Park	II	6	3
124	Ouari Maro	Benin	Classified Forest	Not Reported	204	18
125	Ouémé Boukou	Benin	Classified Forest	Not Reported	1	1
126	Ouémé Superieur	Benin	Classified Forest	Not Reported	49	18
127	Pai River	Nigeria	Forest Reserve	Not Reported	1	1
128	Pama	Burkina Faso	Classified Forest and Partial Wildlife Reserve	IV	15	7
130	Parc National du W du Niger	Niger	National Park	II	84	15
131	Pendjari	Benin	Hunting Zone	VI	239	28
132	Pénessoulou	Benin	Classified Forest	Not Reported	22	8
133	Pic de Fon	Guinea	Classified Forest	Not Reported	6	6
134	Pic de Tibe	Guinea	Classified Forest	Not Reported	4	4
135	Red Volta East	Ghana	Forest Reserve	IV	5	3
136	Rio Cacheu Mangroves	Guinea - Bissau	Natural Park	Not Reported	1	1
137	River Moshi	Nigeria	Forest Reserve	Not Reported	3	3
138	Sahel	Burkina Faso	Sylvo-pastoral Reserve and Partial Wildlife Reserve	IV	708	15
139	Sainyinan	Nigeria	Forest Reserve	Not Reported	3	1
140	Sala	Guinea	Classified Forest	Not Reported	1	1

141	Sanga River	Nigeria	Forest Reserve	Not Reported	1	1
142	Sankan Biriwa (Tingi Hills)	Sierra Leone	No or Non - Hunting Forest Reserve	II	1	1
143	Sapoba	Nigeria	Forest Reserve	Not Reported	1	1
144	Sebore	Nigeria	Forest Reserve	Not Reported	1	1
145	Seguela	Cote d' Ivoire	Classified Forest	Not Reported	1	1
146	Sewa-Waanje	Sierra Leone	Game Reserve	Not Reported	1	1
147	Shai Hills	Ghana	Resource Reserve	VI	2	2
148	Sherigia	Nigeria	Forest Reserve	Not Reported	3	1
149	Tai- National Park	Cote d' Ivoire	National Park	II	7	3
150	Tamou	Niger	Game Reserve	IV	20	5
151	Tchaourou	Benin	Classified Forest	Not Reported	11	5
152	Tere	Burkina Faso	Classified Forest	Not Reported	2	1
153	Tieme	Cote d' Ivoire	Classified Forest	Not Reported	1	1
154	Togo Plateau	Ghana	Forest Reserve	IV	1	1
155	Toui-Kilibo	Benin	Classified Forest	Not Reported	7	5
156	Trois Rivières	Benin	Classified Forest	Not Reported	42	7
157	W (Benin)	Benin	National Park	II	107	14
158	W du Burkina Faso	Burkina Faso	National Park	II	13	7
159	Wara Wara Hills	Sierra Leone	Forest Reserve	Not Reported	6	1
160	Wasaini	Nigeria	Forest Reserve	Not Reported	4	3
161	Wawagi	Nigeria	Forest Reserve	Not Reported	1	1
162	Western Area	Sierra Leone	No or Non - Hunting Forest Reserve	II	3	3
163	Wetland of the W of Niger National Park	Niger	Ramsar Site, Wetland of International Importance	II	98	16
164	Wiaga Kandema	Ghana	Forest Reserve	VI	2	2
165	Yankari	Nigeria	Game Reserve	IV	24	9

Table 3S2: Population of priority CWR in network of protected areas and genebanks

	Taxon	Total number of records	Taxa population in PA	% taxa population in PA	Number of PAs recorded	Taxa population in reserve site	Number of reserve site found	Taxa population in genebanks	% taxa population in genebanks	Taxa for further ex-situ collection
	Cola acuminata (P. Beauv.) Schott & Endl.	110	8	7.27	3	1	NA	NA	NA	Yes
1	Cola altissima Engl.	NA	NA	NA	NA	6	1	NA	NA	Yes
2	Cola angustifolia K. Schum.	13	10	76.9	4	NA	1	NA	NA	Yes
3	Cola argentea Mast.	NA	NA	NA	NA	NA	NA	NA	NA	Yes
4	Cola attiensis Aubrev. & Pellegr.	25	5	20	1	NA	NA	NA	NA	Yes
5	Digitaria barbinodis Henrard	10	NA	NA	NA	14	NA	2	20	Yes
6	Digitaria cillaria (Retz.) Koeler	960	443	46.1	18	NA	2	28	2.91	Yes
7	Digitaria fuscenscens (J. Presl) Henrard	34	NA	NA	NA	1	NA	6	17.64	Yes
8	Digitaria iburua Stapf	10	3	NA	2	NA	1	4	40	Yes
9	Dioscorea abyssinica Hochst. Ex Kunth	1	NA	NA	NA	NA	NA	NA	NA	Yes
10	Dioscorea alata L.	4	NA	NA	NA	NA	NA	4	100	Yes
11	Dioscorea baya De Wild.	2	1	50	1	NA	NA	NA	NA	Yes
12	Dioscorea bulbifera L.	9	1	11.1	1	NA	NA	9	100	Yes
13	Dioscorea burkilliana J. Miege	97	2	2.06	1	5	NA	26	26.8	Yes
14	Dioscorea cayenensis Lam.	246	34	13.8	11	6	2	62	25.2	No
15	Dioscorea minutiflora Engl.	208	29	13.9	12	1	1	75	36.06	No
16	Dioscorea praehensilis Benth.	425	47	11.05	21	NA	1	106	24.94	No
17	Dioscorea quartiniana A. Rich.	42	7	16.6	5	3	NA	2	4.76	Yes

18	Dioscorea sagittifolia Pax	188	139	73.9	6	3	1	1	0.53	Yes
19	Dioscorea sagittifolia var. lecardii (De Wild.) Nkounkou	28	6	21.4	4	2	1	11	39.28	Yes
20	Dioscorea sansibarensis Pax	51	26	50.9	5	NA	1	3	5.88	Yes
21	Dioscorea schimperiana Hochst. ex Kunth	7	1	14.28	1	NA	NA	NA	0	Yes
22	Dioscorea smilacifolia De Wild. & T. Durand	217	49	22.58	14	9	NA	21	9.67	Yes
23	Dioscorea togoensis R. Knuth	474	226	47.67	18	NA	2	13	2.74	Yes
24	Echinochloa colonum (L.) Link	NA	NA	NA	NA	NA	NA	NA	NA	Yes
25	Echinochloa crus- galli (L.) P. Beauv.	5	NA	NA	NA	NA	NA	1	20	Yes
26	Echinochloa crus- pavonis (Kunth) Schult	NA	NA	NA	NA	NA	NA	NA	NA	Yes
27	Echinochloa frumentacea Link	NA	NA	NA	NA	7	NA	NA	NA	Yes
28	Echinochloa pyramidalis (Lam.) Hitchc. & Chase	656	76	11.58	30	NA	2	51	7.77	No
29	Eleusine africana Kenn - O'Byme	30	4	13.3	2	NA	NA	NA	0	Yes
30	Eleusine coracana subsp. coracana (L.) Gaertn.	NA	NA	NA	NA	10	NA	NA	NA	Yes
31	Eleusine indica (L.) Gaertn.	674	97	14.39	38	15	4	41	6.08	Yes
32	Eragrostis japonica (Thunb.) Trin.	176	39	22.16	9	8	1	7	3.97	Yes
33	Eragrostis pilosa (L.) P. Beauv.	774	234	30.23	14	NA	2	20	2.58	Yes
34	Eragrostis prolifera (Sw.) Steud.	NA	NA	NA	NA	NA	NA	NA	NA	Yes
35	Eragrotis unioloides (Retz.) Nees ex Steud.	19	1	5.26	1	NA	NA	NA	NA	Yes
36	Gossypium anomalum Wawra	35	6	17.1	3	NA	NA	NA	NA	Yes
37	Gossypium barbadense Linn.	17	1	5.88	1	NA	NA	NA	NA	Yes
38	Gossypium herbaceum var. acerifolium (Guill. & Perr.) A. Chev.	8	NA	NA	NA	NA	NA	1	12.5	Yes

39	Hordeum bulbosum L	NA	NA	NA	NA	NA	NA	NA	NA	Yes
40	Hordeum vulgare subsp. Spontaneum L.	NA	NA	NA	NA	NA	NA	NA	NA	Yes
41	Ipomoea acanthocarpa (Choisy) Hochst. ex Schweinf. & Asch.	24	8	33.3	2	NA	NA	12	50	Yes
42	Ipomoea alba L.	62	14	22.58	4	28	NA	4	6.45	Yes
43	Ipomoea aquatica Forssk.	679	126	18.55	30	26	4	9	1.32	Yes
44	Ipomoea argentaurata Hallier f.	434	158	36.4	27	4	3	19	4.37	Yes
45	Ipomoea asarifolia (Desr.) Roem. & Schult.	265	44	16.6	13	3	3	13	4.9	Yes
46	Ipomoea barteri Baker	61	10	16.39	6	5	1	11	18.03	Yes
47	Ipomoea blepharophylla Hallier f.	45	16	35.55	8	NA	2	NA	NA	Yes
48	Ipomoea chrysochaetia Hallier f.	13	1	7.69	1	1	NA	2	15.38	Yes
49	Ipomoea coptica (L.) Roth ex Roem. & Schult.	137	32	23.35	7	NA	1	NA	NA	Yes
50	Ipomoea intrapilosa Rose	NA	NA	NA	NA	NA	NA	NA	NA	Yes
51	Ipomoea ochracea (Lindl.) Sweet	6	NA	NA	NA	NA	NA	NA	NA	Yes
52	Ipomoea prismatosyphon Welw.	NA	NA	NA	NA	11	NA	NA	NA	Yes
53	Ipomoea rubens Choisy	93	30	32.25	7	NA	2	6	6.45	Yes
54	Manihot carthagenesis (Jacq.) Mull. Arg.	NA	NA	NA	NA	NA	NA	NA	NA	Yes
55	Manihot carthagenesis subsp. glaziovii (Mull. Arg.) Allem	24	2	8.33	2	NA	NA	5	20.83	Yes
56	Manihot dichotoma Ule	1	NA	NA	NA	NA	NA	NA	NA	Yes
57	Manihot esculenta subsp. flabellifolia Crantz	NA	NA	NA	NA	NA	NA	NA	NA	Yes
58	Manihot esculenta subsp. peruviana Crantz	NA	NA	NA	NA	35	NA	NA	NA	Yes
59	Oryza barthi A. Chev.	2396	150	6.26	30	3	4	610	25.45	No
60	Oryza brachyantha A. Chev. & Roeehr.	93	37	39.78	6	NA	1	33	35.48	Yes
61	Oryza eichingeri Peter	9	6	66.66	1	51	NA	1	11.11	Yes

62	Oryza glaberrima Steud.	3594	161	4.47	37	25	1	2670	74.29	No
63	Oryza longistaminata A. Chev. & Roehr.	1030	153	14.85	26	NA	4	562	54.56	No
64	Oryza puntata Kotschy ex Steud.	78	10	12.82	4	3	NA	39	50	Yes
65	Panicum comorense Mez	15	4	NA	2	NA	1	2	13.33	Yes
66	Panicum repens L.	400	45	26.66	14	NA	NA	11	2.75	Yes
67	Phaseolus lunatus Linn	NA	NA	NA	NA	NA	NA	NA	NA	Yes
68	Phaseolus vulgaris subsp. abarigineus L.	NA	NA	NA	NA	NA	NA	NA	NA	Yes
69	Phaseolus vulgaris var. abarigineus L.	NA	NA	NA	NA	NA	NA	NA	NA	Yes
70	Phoenix reclinata Jacq.	333	86	25.82	20	4	NA	13	3.9	Yes
71	Saccharum spontaneum subsp. aegyptiacum (Willd.) Hack.	4	4	100	1	NA	1	NA	NA	Yes
72	Saccharum spontaneum subsp. spontaneum L.	NA	NA	NA	NA	NA	NA	NA	NA	Yes
73	Sorghum bicolor subsp. Verticilliflorum (L.) Moench	NA	NA	NA	NA	NA	NA	NA	NA	Yes
74	Sorghum drummodii (Neee ex A. Rich.) Millsp. & Chase	5	NA	NA	NA	NA	NA	NA	NA	Yes
75	Sorghum purpurreosericeum (Hoch. Ex A. Rich) Schweinf. & Asch.	3	NA	NA	NA	NA	NA	NA	NA	Yes
76	Sorghum virgatum (Hack.) Stapf	NA	NA	NA	NA	NA	NA	NA	NA	Yes
77	Triticum turgidum L.	2	NA	NA	NA	NA	NA	2	100	Yes
78	Triticum turgidum subsp. durum (Desf.) Husn.	NA	NA	NA	NA	14	NA	NA	NA	Yes
79	Vigna ambacensis Welw. ex Bak.	574	81	14.11	21	6	3	242	42.16	No
80	Vigna desmodiodes Wilczek	17	6	35.29	2	14	2	4	23.52	Yes
81	Vigna filicaulis Hepper	399	186	46.61	24	46	3	37	9.27	Yes
82	Vigna gracilis (Guill. & Perr.) Hook. f.	544	138	25.36	24	NA	3	130	23.89	No
83	Vigna luteola (Jacq.) Benth.	229	38	16.59	8	NA	NA	50	21.83	No
84	Vigna macrorrhyncha (Harms) Milne - Redhead	NA	NA	NA	NA	NA	NA	NA	NA	Yes
85	Vigna marina (Burm.) Merill	40	2	5	1	3	NA	13	32.5	Yes

86	Vigna multinervis Hutch. & Dalz.	176	43	24.43	7	9	1	41	23.29	Yes
87	Vigna nigritia Hook. f.	244	21	8.6	9	NA	2	28	11.47	Yes
88	Vigna oblongifolia A. Rich.	167	1	0.59	1	56	NA	11	6.58	Yes
89	Vigna racemosa (G. Don) Hutch. & Dalz.	1352	425	31.43	40	13	4	313	23.15	No
90	Vigna reticulata Hook. f.	578	156	26.98	21	NA	3	152	26.29	No
91	Vigna unguiculata subsp. aduensis (L.) Pasquet	NA	NA	NA	NA	NA	NA	NA	NA	Yes
92	Vigna unguiculata subsp. alba (G.Don) Pasquet	NA	NA	NA	NA	NA	NA	NA	NA	Yes
93	Vigna unguiculata subsp. baoulensis (A.Chev.) Pasquet	39	6	15.38	3	NA	NA	6	15.38	Yes
94	Vigna unguiculata subsp. burundiensis Pasquet	NA	NA	NA	NA	2	NA	NA	NA	Yes
95	Vigna unguiculata subsp. dekindtiana (Harms) Verdc.	333	19	5.7	7	NA	1	149	44.74	No
96	Vigna unguiculata subsp. letouzeyi Pasquet	6	1	16.66	1	NA	NA	NA	NA	Yes
97	Vigna unguiculata subsp. pawekiae Pasquet	2	1	50	1	NA	NA	NA	NA	Yes
98	Vigna unguiculata subsp. pubescens (R.Wilczek) Pasquet	2	1	50	1	NA	NA	NA	NA	Yes
99	Vigna unguiculata subsp. stenophylla (Harv.) Marechal & al.	13	NA	NA	NA	NA	NA	12	92.3	Yes
100	Vigna unguiculata subsp. tenuis (E.Mey) Marechal & al.	NA	NA	NA	NA	4	NA	NA	NA	Yes
101	Vigna unguiculata subsp. unguiculata var. spontanea (Schweinf.) Pasquet	49	13	26.53	NA	NA	2	14	28.57	Yes
102	Ground total	20,125	3730			457	75	5720		

Table 3S3: Number of priority CWR and taxa population in protected areas in West Africa

		Total number of records	Number of records in PA	Agoua	Agrimey	Air and Tenere Natural Reserves	Alawa	Aledjo	Amakpave	Anguededou	Ansongo Giraffe Reserve	Apepesu River	Atakora	Atcherigbe	Atilakoutse	Auya	Azagny National Park	Badiar	Badonou	Bam Ngelzarma	Banco National Park	Bansie	Baobolong	Baoule	Barawa	Barrage de Ouagadougou	Bassari - Montagne	Besso	Bia National Park	Biliri Hills	Bissiga	Borgu	Boucle de la Pendjari	Bui	Central Shendam
1	Cola acuminata (P. Beauv.) Schott & Endl.	110	8																																
2	Cola altissima Engl.																											1							
3	Cola angustifolia K. Schum.	13	10																																
4	Cola argentea Mast.																																		
5	Cola attiensis Aubrev. & Pellegr.	25	5																		3														
6	Digitaria barbinodis Henrard	10																																	
7	Digitaria cillaria (Retz.) Koeler	960	443															4		1															
8	Digitaria fuscenscens (J. Presl) Henrard	34																																	
9	Digitaria iburua Stapf	10	3																																
10	Dioscorea abyssinica Hochst. Ex Kunth	1																																	

11	Dioscorea alata L.	4																																	
12	Dioscorea baya De Wild.	2	1							1																									
13	Dioscorea bulbifera L.	9	1																																
14	Dioscorea burkilliana J. Miege	97	2																																
15	Dioscorea cayenensis Lam.	246	34		1																							2						3		
16	Dioscorea minutiflora Engl.	208	29																	7								4						
17	Dioscorea praehensilis Benth.	425	47																																
18	Dioscorea quartiniana A. Rich.	42	7	2																															
19	Dioscorea sagittifolia Pax	188	139																																
20	Dioscorea sagittifolia var. lecardii (De Wild.) Nkounkou	28	6																																
21	Dioscorea sansibarensis Pax	51	26																													2		
22	Dioscorea schimperiana Hochst. ex Kunth	7	1																																
23	Dioscorea smilacifolia De Wild. & T. Durand	217	49																	5								4						
24	Dioscorea togoensis R. Knuth	474	226																													4		
25	Echinochloa colonum (L.) Link																																		
26	Echinochloa crus- galli (L.) P. Beauv.	5																																	
27	Echinochloa crus- pavonis (Kunth) Schult																																		
28	Echinochloa frumentacea Link																																		
29	Echinochloa pyramidalis (Lam.) Hitchc. & Chase	656	76											1			1				1									1	1		6		
30	Eleusine africana Kenn - O'Byme	30	4																																
31	Eleusine coracana subsp. coracana (L.) Gaertn.																																		
32	Eleusine indica (L.) Gaertn.	674	97											1				1														2		
33	Eragrostis japonica (Thunb.) Trin.	176	39			1																									1				
34	Eragrostis pilosa (L.) P. Beauv.	774	234															1																	
35	Eragrostis prolifera (Sw.) Steud.																																		

36	Eragrotis unioloides (Retz.) Nees ex Steud.	19	1								1																								
37	Gossypium anomalum Wawra	35	6			2					1																								
38	Gossypium barbadense Linn.	17	1																																
39	Gossypium herbaceum var. acerifolium (Guill. & Perr.) A. Chev.	8																																	
40	Hordeum bulbosum L																																		
41	Hordeum vulgare subsp. Spontaneum L.																																		
42	Ipomoea acanthocarpa (Choisy) Hochst. ex Schweinf. & Asch.	24	8										3																						
43	Ipomoea alba L.	62	14										4																						
44	Ipomoea aquatica Forssk.	679	126		2																					1							8		
45	Ipomoea argentaurata Hallier f.	434	158						2				4																			3	6		
46	Ipomoea asarifolia (Desr.) Roem. & Schult.	265	44																						13							4	2		
47	Ipomoea barteri Baker	61	10																																
48	Ipomoea blepharophylla Hallier f.	45	16																																
49	Ipomoea chrysochaetia Hallier f.	13	1																																
50	Ipomoea coptica (L.) Roth ex Roem. & Schult.	137	32																																
51	Ipomoea intrapilosa Rose																																		
52	Ipomoea ochracea (Lindl.) Sweet	6																																	
53	Ipomoea prismatosyphon Welw.																																		
54	Ipomoea rubens Choisy	93	30																																
55	Manihot carthagenesis (Jacq.) Mull. Arg.																																		
56	Manihot carthagenesis subsp. glaziovii (Mull. Arg.) Allem	24	2																																
57	Manihot dichotoma Ule	1																																	
58	Manihot esculenta subsp. flabellifolia Crantz																																		

59	Manihot esculenta subsp. peruviana Crantz																																		
60	Oryza barthi A. Chev.	2396	150														2														1		3		
61	Oryza brachyantha A. Chev. & Roeehr.	93	37																																
62	Oryza eichingeri Peter	9	6																																
63	Oryza glaberrima Steud.	3594	161									3			3			8					19								4				1
64	Oryza longistaminata A. Chev. & Roehr.	1030	153													1	1		8		1												3		
65	Oryza puntata Kotschy ex Steud.	78	10																																
66	Panicum comorense Mez	15	4																																
67	Panicum repens L.	400	45			1																										1	3		
68	Phaseolus lunatus Linn																																		
69	Phaseolus vulgaris subsp. abarigineus L.																																		
70	Phaseolus vulgaris var. abarigineus L.																																		
71	Phoenix reclinata Jacq.	333	86					1																										1	
72	Saccharum spontaneum subsp. aegyptiacum (Willd.) Hack.	4	4																																
73	Saccharum spontaneum subsp. spontaneum L.																																		
74	Sorghum bicolor subsp. Verticilliflorum (L.) Moench																																		
75	Sorghum drummodii (Neee ex A. Rich.) Millsp. & Chase	5																																	
76	Sorghum purpurreosericeum (Hoch. Ex A. Rich) Schweinf. & Asch.	3																																	
77	Sorghum virgatum (Hack.) Stapf																																		
78	Triticum turgidum L.	2																																	
79	Triticum turgidum subsp. durum (Desf.) Husn.																																		
80	Vigna ambacensis Welw. ex Bak.	574	81				3																												
81	Vigna desmodiodes Wilczek	17	6																																

82	Vigna filicaulis Hepper	399	186															2															3		
83	Vigna gracilis (Guill. & Perr.) Hook. f.	544	138																														4		
84	Vigna luteola (Jacq.) Benth.	229	38																					1											
85	Vigna macrorrhyncha (Harms) Milne - Redhead																																		
86	Vigna marina (Burm.) Merill	40	2																																
87	Vigna multinervis Hutch. & Dalz.	176	43																																
88	Vigna nigritia Hook. f.	244	21																																
89	Vigna oblongifolia A. Rich.	167	1			1																													
90	Vigna racemosa (G. Don) Hutch. & Dalz.	1352	425	2			3						5									1											11		
91	Vigna reticulata Hook. f.	578	156															2															3		
92	Vigna unguiculata subsp. aduensis (L.) Pasquet																																		
93	Vigna unguiculata subsp. alba (G.Don) Pasquet																																		
94	Vigna unguiculata subsp. baoulensis (A.Chev.) Pasquet	39	6																																
95	Vigna unguiculata subsp. burundiensis Pasquet																																		
96	Vigna unguiculata subsp. dekindtiana (Harms) Verdc.	333	19																																
97	Vigna unguiculata subsp. letouzeyi Pasquet	6	1																																
98	Vigna unguiculata subsp. pawekiae Pasquet	2	1																																
99	Vigna unguiculata subsp. pubescens (R.Wilczek) Pasquet	2	1																																
100	Vigna unguiculata subsp. stenophylla (Harv.) Marechal & al.	13																																	
101	Vigna unguiculata subsp. tenuis (E.Mey) Marechal & al.																																		
102	Vigna unguiculata subsp. unguiculata var. spontanea (Schweinf.) Pasquet	49	13																														2		

	Total number of occurrence records	20125	3730	4	3	5	6	1	2	1	1	3	16	2	3	1	4	18	8	1	17	1	19	1	13	1	2	1	8	1	7	8	65	1	1
	Number of CWR			2	2	4	2	1	1	1	1	1	4	2	1	1	3	6	1	1	5	1	1	1	1	1	1	1	2	1	4	3	16	1	1

Table 3S3: Number of priority CWR and taxa population in protected areas in West Africa (Contd)

		Cliff of Bandiagara (Land of the Dogons)	Comoe National Park	Cousignaki	Cross River	Dagida	Dan	Dankaiwa	Delta du Saloum	Diecke	Digya	Dinderesso	Djamde	Djigbe	Djona	Djoudj National Bird Sanctuary	Dogo	Doro	Dosso	Dulombi	East Nimba Nature Reserve	Ekenwan	Eto	Farangbaia	Fazao - Malfakassa	Ferlo Nord	Ferlo- Sud	Gambaga Scarp East	Gambari	Gashaka - Gumti	Gazabure	Gbele	Gitata	Gonse
1	Cola acuminata (P. Beauv.) Schott & Endl.																2																	
2	Cola altissima Engl.									1																								
3	Cola angustifolia K. Schum.																							1										
4	Cola argentea Mast.																																	
5	Cola attiensis Aubrev. & Pellegr.																																	
6	Digitaria barbinodis Henrard																																	
7	Digitaria cillaria (Retz.) Koeler	17																			1						1	1				1		
8	Digitaria fuscenscens (J. Presl) Henrard																																	
9	Digitaria iburua Stapf																																	

10	Dioscorea abyssinica Hochst. Ex Kunth																																	
11	Dioscorea alata L.																																	
12	Dioscorea baya De Wild.																																	
13	Dioscorea bulbifera L.																					1												
14	Dioscorea burkilliana J. Miege																																	
15	Dioscorea cayenensis Lam.																						2		1									
16	Dioscorea minutiflora Engl.				1												2				1								1					
17	Dioscorea praehensilis Benth.				2					1							2	2											1					
18	Dioscorea quartiniana A. Rich.																1																	
19	Dioscorea sagittifolia Pax																																	
20	Dioscorea sagittifolia var. lecardii (De Wild.) Nkounkou																																	
21	Dioscorea sansibarensis Pax		17																															
22	Dioscorea schimperiana Hochst. ex Kunth																																	
23	Dioscorea smilacifolia De Wild. & T. Durand		1		2										10						1								3					
24	Dioscorea togoensis R. Knuth		57											1	10		10																	
25	Echinochloa colonum (L.) Link																																	
26	Echinochloa crus- galli (L.) P. Beauv.																																	
27	Echinochloa crus- pavonis (Kunth) Schult																																	
28	Echinochloa frumentacea Link																																	
29	Echinochloa pyramidalis (Lam.) Hitchc. & Chase		4																1							1	7	1						3
30	Eleusine africana Kenn - O'Byme	2																																
31	Eleusine coracana subsp. coracana (L.) Gaertn.																																	
32	Eleusine indica (L.) Gaertn.	1																			2						1	1	1	2				
33	Eragrostis japonica (Thunb.) Trin.		6																															1
34	Eragrostis pilosa (L.) P. Beauv.	1														1										2	1							

35	Eragrostis prolifera (Sw.) Steud.																																	
36	Eragrotis unioloides (Retz.) Nees ex Steud.																																	
37	Gossypium anomalum Wawra																																	
38	Gossypium barbadense Linn.																																	
39	Gossypium herbaceum var. acerifolium (Guill. & Perr.) A. Chev.																																	
40	Hordeum bulbosum L																																	
41	Hordeum vulgare subsp. Spontaneum L.																																	
42	Ipomoea acanthocarpa (Choisy) Hochst. ex Schweinf. & Asch.																																	
43	Ipomoea alba L.				1																								1					
44	Ipomoea aquatica Forssk.	1									1					5	2		1															2
45	Ipomoea argentaurata Hallier f.		17										1		4																			
46	Ipomoea asarifolia (Desr.) Roem. & Schult.																		1						1		4							
47	Ipomoea barteri Baker		2																															
48	Ipomoea blepharophylla Hallier f.		3																2															
49	Ipomoea chrysochaetia Hallier f.																																	
50	Ipomoea coptica (L.) Roth ex Roem. & Schult.																		1								3							
51	Ipomoea intrapilosa Rose																																	
52	Ipomoea ochracea (Lindl.) Sweet																																	
53	Ipomoea prismatosyphon Welw.																																	
54	Ipomoea rubens Choisy										1								9															
55	Manihot carthagenesis (Jacq.) Mull. Arg.																																	
56	Manihot carthagenesis subsp. glaziovii (Mull. Arg.) Allem																																	
57	Manihot dichotoma Ule																																	

58	Manihot esculenta subsp. flabellifolia Crantz																																	
59	Manihot esculenta subsp. peruviana Crantz																																	
60	Oryza barthi A. Chev.	2	17													1				3						6	6				1			2
61	Oryza brachyantha A. Chev. & Roeehr.		15																															
62	Oryza eichingeri Peter		6																															
63	Oryza glaberrima Steud.	7	1				4	3												7						4							1	
64	Oryza longistaminata A. Chev. & Roehr.		3																5	1						1					1	1		
65	Oryza puntata Kotschy ex Steud.		3																															
66	Panicum comorense Mez																												1					
67	Panicum repens L.		3																								15							
68	Phaseolus lunatus Linn																																	
69	Phaseolus vulgaris subsp. abarigineus L.																																	
70	Phaseolus vulgaris var. abarigineus L.																																	
71	Phoenix reclinata Jacq.		3						2			1								1							7							
72	Saccharum spontaneum subsp. aegyptiacum (Willd.) Hack.																																	
73	Saccharum spontaneum subsp. spontaneum L.																																	
74	Sorghum bicolor subsp. Verticilliflorum (L.) Moench																																	
75	Sorghum drummodii (Neee ex A. Rich.) Millsp. & Chase																																	
76	Sorghum purpurreosericeum (Hoch. Ex A. Rich) Schweinf. & Asch.																																	
77	Sorghum virgatum (Hack.) Stapf																																	
78	Triticum turgidum L.																																	
79	Triticum turgidum subsp. durum (Desf.) Husn.																																	

80	Vigna ambacensis Welw. ex Bak.	3	3	2											10				3								2							
81	Vigna desmodiodes Wilczek																																	
82	Vigna filicaulis Hepper		81								1				11		2		2						1									
83	Vigna gracilis (Guill. & Perr.) Hook. f.		27		1												6										2							
84	Vigna luteola (Jacq.) Benth.																																	
85	Vigna macrorrhyncha (Harms) Milne - Redhead																																	
86	Vigna marina (Burm.) Merill																																	
87	Vigna multinervis Hutch. & Dalz.		30																															
88	Vigna nigritia Hook. f.																																	
89	Vigna oblongifolia A. Rich.																																	
90	Vigna racemosa (G. Don) Hutch. & Dalz.	5	33			3					1				11		5		15		1					2	2							
91	Vigna reticulata Hook. f.		63										1		2		13		4															
92	Vigna unguiculata subsp. aduensis (L.) Pasquet																																	
93	Vigna unguiculata subsp. alba (G.Don) Pasquet																																	
94	Vigna unguiculata subsp. baoulensis (A.Chev.) Pasquet		3																															
95	Vigna unguiculata subsp. burundiensis Pasquet																																	
96	Vigna unguiculata subsp. dekindtiana (Harms) Verdc.	1	9																2															
97	Vigna unguiculata subsp. letouzeyi Pasquet																																	
98	Vigna unguiculata subsp. pawekiae Pasquet																																	
99	Vigna unguiculata subsp. pubescens (R.Wilczek) Pasquet																																	
100	Vigna unguiculata subsp. stenophylla (Harv.) Marechal & al.																																	
101	Vigna unguiculata subsp. tenuis (E.Mey) Marechal & al.																																	

102	Vigna unguiculata subsp. unguiculata var. spontanea (Schweinf.) Pasquet																		2															
	Total number of occurrence records	40	407	2	7	3	4	3	2	2	4	1	2	1	58	7	45	2	48	12	6	1	2	1	3	16	51	3	8	2	2	2	1	8
	Number of CWR	10	24	1	5	1	1	1	1	2	4	1	2	1	7	3	10	1	13	4	5	1	1	1	3	6	12	3	6	1	2	2	1	4

Table 3S3: Number of priority CWR and taxa population in protected areas in West Africa (Contd)

		Goudi	Gougoun	Gourma Elephant Reserve	Grebo Natural Forest Park	Ibadan	Idanre	Ilaro	Iles Ehotile National Park	Iggi River	Illoka'oje	Iwa River	Kabore - Tambi	Kafnikoro	Kainji Lake	Kalakpa	Kenebaoule	Ketou	Koflande	Kpashimi	Kuru Hills	La Lama Nord	La Lama Sud	La Sota	Lagoa de Cufada	L'Alibori Superieur	Lili	Logozohe	Loma Mountains	Mabi/Yaya	Mando Road South
1	Cola acuminata (P. Beauv.) Schott & Endl.																														
2	Cola altissima Engl.																														
3	Cola angustifolia K. Schum.																														
4	Cola argentea Mast.																														
5	Cola attiensis Aubrev. & Pellegr.																														
6	Digitaria barbinodis Henrard																														
7	Digitaria cillaria (Retz.) Koeler			2																									1		
8	Digitaria fuscenscens (J. Presl) Henrard																														

9	Digitaria iburua Stapf																														
10	Dioscorea abyssinica Hochst. Ex Kunth																														
11	Dioscorea alata L.																														
12	Dioscorea baya De Wild.																														
13	Dioscorea bulbifera L.																														
14	Dioscorea burkilliana J. Miege																														
15	Dioscorea cayenensis Lam.						1															14									
16	Dioscorea minutiflora Engl.															1															
17	Dioscorea praehensilis Benth.							1					1		2	1						11					1		3		
18	Dioscorea quartiniana A. Rich.															1															
19	Dioscorea sagittifolia Pax																					111			4						
20	Dioscorea sagittifolia var. lecardii (De Wild.) Nkounkou																												1		
21	Dioscorea sansibarensis Pax																					1				1					
22	Dioscorea schimperiana Hochst. ex Kunth																														
23	Dioscorea smilacifolia De Wild. & T. Durand				2																									1	
24	Dioscorea togoensis R. Knuth																	4				1	1				1				
25	Echinochloa colonum (L.) Link																														
26	Echinochloa crus-galli (L.) P. Beauv.																														
27	Echinochloa crus-pavonis (Kunth) Schult																														

28	Echinochloa frumentacea Link																														
29	Echinochloa pyramidalis (Lam.) Hitchc. & Chase		1	4					1			1										1			2						
30	Eleusine africana Kenn - O'Byme																														
31	Eleusine coracana subsp. coracana (L.) Gaertn.																														
32	Eleusine indica (L.) Gaertn.	1				1		1										3				1	3			2			1		
33	Eragrostis japonica (Thunb.) Trin.			2																	1										
34	Eragrostis pilosa (L.) P. Beauv.			3																											
35	Eragrostis prolifera (Sw.) Steud.																														
36	Eragrotis unioloides (Retz.) Nees ex Steud.																														
37	Gossypium anomalum Wawra																														
38	Gossypium barbadense Linn.																														
39	Gossypium herbaceum var. acerifolium (Guill. & Perr.) A. Chev.																														
40	Hordeum bulbosum L																														
41	Hordeum vulgare subsp. Spontaneum L.																														
42	Ipomoea acanthocarpa (Choisy) Hochst. ex Schweinf. & Asch.																														
43	Ipomoea alba L.																														
44	Ipomoea aquatica Forssk.		1						1				1									4	4								
45	Ipomoea argentaurata Hallier f.		9												3				1	1				5							

46	Ipomoea asarifolia (Desr.) Roem. & Schult.														4	1						1									2
47	Ipomoea barteri Baker																														
48	Ipomoea blepharophylla Hallier f.																														
49	Ipomoea chrysochaetia Hallier f.																												1		
50	Ipomoea coptica (L.) Roth ex Roem. & Schult.																														
51	Ipomoea intrapilosa Rose																														
52	Ipomoea ochracea (Lindl.) Sweet																														
53	Ipomoea prismatosyphon Welw.																														
54	Ipomoea rubens Choisy																														
55	Manihot carthagenesis (Jacq.) Mull. Arg.																														
56	Manihot carthagenesis subsp. glaziovii (Mull. Arg.) Allem																					1									
57	Manihot dichotoma Ule																														
58	Manihot esculenta subsp. flabellifolia Crantz																														
59	Manihot esculenta subsp. peruviana Crantz																														
60	Oryza barthi A. Chev.		3	2																		6	1	3							
61	Oryza brachyantha A. Chev. & Roeehr.																								4						
62	Oryza eichingeri Peter																														

63	Oryza glaberrima Steud.		1	1						1							1		1						5		2				
64	Oryza longistaminata A. Chev. & Roehr.		1	2						1																					
65	Oryza puntata Kotschy ex Steud.																					1									
66	Panicum comorense Mez																														
67	Panicum repens L.			1					1						1																
68	Phaseolus lunatus Linn																														
69	Phaseolus vulgaris subsp. abarigineus L.																														
70	Phaseolus vulgaris var. abarigineus L.																														
71	Phoenix reclinata Jacq.		1																						8	1					
72	Saccharum spontaneum subsp. aegyptiacum (Willd.) Hack.																														
73	Saccharum spontaneum subsp. spontaneum L.																														
74	Sorghum bicolor subsp. Verticilliflorum (L.) Moench																														
75	Sorghum drummodii (Neee ex A. Rich.) Millsp. & Chase																														
76	Sorghum purpurreosericeum (Hoch. Ex A. Rich) Schweinf. & Asch.																														
77	Sorghum virgatum (Hack.) Stapf																														
78	Triticum turgidum L.																														

79	Triticum turgidum subsp. durum (Desf.) Husn.																														
80	Vigna ambacensis Welw. ex Bak.													2				1				1					3				
81	Vigna desmodiodes Wilczek																														
82	Vigna filicaulis Hepper		2																						2		1				
83	Vigna gracilis (Guill. & Perr.) Hook. f.																	2				1			8			1	6		
84	Vigna luteola (Jacq.) Benth.																					1	1		2				4		
85	Vigna macrorrhyncha (Harms) Milne - Redhead																														
86	Vigna marina (Burm.) Merill																														
87	Vigna multinervis Hutch. & Dalz.																										5				
88	Vigna nigritia Hook. f.																												3		
89	Vigna oblongifolia A. Rich.																														
90	Vigna racemosa (G. Don) Hutch. & Dalz.		4											2		1		2									2		14		
91	Vigna reticulata Hook. f.																	9											7		
92	Vigna unguiculata subsp. aduensis (L.) Pasquet																														
93	Vigna unguiculata subsp. alba (G.Don) Pasquet																														
94	Vigna unguiculata subsp. baoulensis (A.Chev.) Pasquet																														
95	Vigna unguiculata subsp. burundiensis Pasquet																														

96	Vigna unguiculata subsp. dekindtiana (Harms) Verdc.																								2						
97	Vigna unguiculata subsp. letouzeyi Pasquet										1																				
98	Vigna unguiculata subsp. pawekiae Pasquet																														
99	Vigna unguiculata subsp. pubescens (R.Wilczek) Pasquet																														
100	Vigna unguiculata subsp. stenophylla (Harv.) Marechal & al.																														
101	Vigna unguiculata subsp. tenuis (E.Mey) Marechal & al.																														
102	Vigna unguiculata subsp. unguiculata var. spontanea (Schweinf.) Pasquet																					1	1								
	Total number of occurrence records	1	23	17	2	1	1	2	3	2	1	1	2	4	10	5	1	21	2	1	1	157	11	8	38	4	15	1	42	1	2
	Number of CWR	1	9	8	1	1	1	2	3	2	1	1	2	2	4	5	1	6	2	1	1	16	6	2	9	3	7	1	10	1	2

Table 3S3: Number of priority CWR and taxa population in protected areas in West Africa (Contd)

		Marago River	Marahoue National Park	Massif du Ziama	Mayo Ndaga	Minna	Mole	Monogaga	Mont Sangbe National Park	Monts Kouffe	Monts Nimba	Mopri	Mt. Yonon	Mount Nimba Integral Reserve	Nasarawa	N'Dama	Ndiael	Niangoloko	Nimba West	Niokolo- Koba National Park	Oban Group	Obaretin	Ohumbe	Oiseaux du Djoudj	Okomu	Old Oyo	Olokemeji	Omo	Oti - Keran	Ouari Maro	Oueme Boukou
1	Cola acuminata (P. Beauv.) Schott & Endl.																								4						
2	Cola altissima Engl.																														
3	Cola angustifolia K. Schum.										6		2																		
4	Cola argentea Mast.																														
5	Cola attiensis Aubrev. & Pellegr.																														
6	Digitaria barbinodis Henrard																														
7	Digitaria cillaria (Retz.) Koeler	1																		12											
8	Digitaria fuscenscens (J. Presl) Henrard																														
9	Digitaria iburua Stapf														1														2		
10	Dioscorea abyssinica Hochst. Ex Kunth																														
11	Dioscorea alata L.																														
12	Dioscorea baya De Wild.																														

13	Dioscorea bulbifera L.																														
14	Dioscorea burkilliana J. Miege																													1	
15	Dioscorea cayenensis Lam.																													1	
16	Dioscorea minutiflora Engl.										6																1	1			
17	Dioscorea praehensilis Benth.							1		7		1									1									1	
18	Dioscorea quartiniana A. Rich.									2																					
19	Dioscorea sagittifolia Pax									14										3											
20	Dioscorea sagittifolia var. lecardii (De Wild.) Nkounkou																			3										1	
21	Dioscorea sansibarensis Pax																														
22	Dioscorea schimperiana Hochst. ex Kunth																														
23	Dioscorea smilacifolia De Wild. & T. Durand												1						1												
24	Dioscorea togoensis R. Knuth									33	5																			54	
25	Echinochloa colonum (L.) Link																														
26	Echinochloa crus-galli (L.) P. Beauv.																														
27	Echinochloa crus-pavonis (Kunth) Schult																														
28	Echinochloa frumentacea Link																														
29	Echinochloa pyramidalis (Lam.) Hitchc. & Chase			1			1									1										1					
30	Eleusine africana Kenn - O'Byme																														

31	Eleusine coracana subsp. coracana (L.) Gaertn.																														
32	Eleusine indica (L.) Gaertn.	1		1			1			14	1									6			1			1	1	2		6	
33	Eragrostis japonica (Thunb.) Trin.																			15										2	
34	Eragrostis pilosa (L.) P. Beauv.																			6				1						3	
35	Eragrostis prolifera (Sw.) Steud.																														
36	Eragrotis unioloides (Retz.) Nees ex Steud.																														
37	Gossypium anomalum Wawra																														
38	Gossypium barbadense Linn.																														
39	Gossypium herbaceum var. acerifolium (Guill. & Perr.) A. Chev.																														
40	Hordeum bulbosum L																														
41	Hordeum vulgare subsp. Spontaneum L.																														
42	Ipomoea acanthocarpa (Choisy) Hochst. ex Schweinf. & Asch.																														
43	Ipomoea alba L.																														
44	Ipomoea aquatica Forssk.						3			2										15		1		3							
45	Ipomoea argentaurata Hallier f.		1							11										18										8	
46	Ipomoea asarifolia (Desr.) Roem. & Schult.										1																				
47	Ipomoea barteri Baker																			3										1	

48	Ipomoea blepharophylla Hallier f.		1																	3						1					
49	Ipomoea chrysochaetia Hallier f.																														
50	Ipomoea coptica (L.) Roth ex Roem. & Schult.																														
51	Ipomoea intrapilosa Rose																														
52	Ipomoea ochracea (Lindl.) Sweet																														
53	Ipomoea prismatosyphon Welw.																														
54	Ipomoea rubens Choisy																														
55	Manihot carthagenesis (Jacq.) Mull. Arg.																														
56	Manihot carthagenesis subsp. glaziovii (Mull. Arg.) Allem																														
57	Manihot dichotoma Ule																														
58	Manihot esculenta subsp. flabellifolia Crantz																														
59	Manihot esculenta subsp. peruviana Crantz																														
60	Oryza barthi A. Chev.									7	1									27				1							
61	Oryza brachyantha A. Chev. & Roeehr.																			3											
62	Oryza eichingeri Peter																														
63	Oryza glaberrima Steud.			4		1			2							1	2			51			1								
64	Oryza longistaminata A. Chev. & Roehr.						1													15											

65	Oryza puntata Kotschy ex Steud.																														
66	Panicum comorense Mez																									3					
67	Panicum repens L.																								1						
68	Phaseolus lunatus Linn																														
69	Phaseolus vulgaris subsp. abarigineus L.																														
70	Phaseolus vulgaris var. abarigineus L.																														
71	Phoenix reclinata Jacq.		1							2								4												7	
72	Saccharum spontaneum subsp. aegyptiacum (Willd.) Hack.																														
73	Saccharum spontaneum subsp. spontaneum L.																														
74	Sorghum bicolor subsp. Verticilliflorum (L.) Moench																														
75	Sorghum drummodii (Neee ex A. Rich.) Millsp. & Chase																														
76	Sorghum purpurreosericeum (Hoch. Ex A. Rich) Schweinf. & Asch.																														
77	Sorghum virgatum (Hack.) Stapf																														
78	Triticum turgidum L.																														
79	Triticum turgidum subsp. durum (Desf.) Husn.																														
80	Vigna ambacensis Welw. ex Bak.						6			3										9										2	

81	Vigna desmodiodes Wilczek										2									4											
82	Vigna filicaulis Hepper		1							12										9						1				11	
83	Vigna gracilis (Guill. & Perr.) Hook. f.				2		1			11	27			1						15										10	
84	Vigna luteola (Jacq.) Benth.																													7	
85	Vigna macrorrhyncha (Harms) Milne - Redhead																														
86	Vigna marina (Burm.) Merill																														
87	Vigna multinervis Hutch. & Dalz.		1							2	3																				
88	Vigna nigritia Hook. f.						2			1	3									6									1	1	
89	Vigna oblongifolia A. Rich.																														
90	Vigna racemosa (G. Don) Hutch. & Dalz.						3			106	6			2					1	24										76	
91	Vigna reticulata Hook. f.						4			4										6									3	12	1
92	Vigna unguiculata subsp. aduensis (L.) Pasquet																														
93	Vigna unguiculata subsp. alba (G.Don) Pasquet																														
94	Vigna unguiculata subsp. baoulensis (A.Chev.) Pasquet																														
95	Vigna unguiculata subsp. burundiensis Pasquet																														
96	Vigna unguiculata subsp. dekindtiana (Harms) Verdc.						3																								

97	Vigna unguiculata subsp. letouzeyi Pasquet																														
98	Vigna unguiculata subsp. pawekiae Pasquet																														
99	Vigna unguiculata subsp. pubescens (R.Wilczek) Pasquet						1																								
100	Vigna unguiculata subsp. stenophylla (Harv.) Marechal & al.																														
101	Vigna unguiculata subsp. tenuis (E.Mey) Marechal & al.																														
102	Vigna unguiculata subsp. unguiculata var. spontanea (Schweinf.) Pasquet																														
	Total number of occurrence records	2	5	6	2	1	26	1	2	250	63	1	3	3	1	2	2	4	2	252	1	1	2	5	4	5	5	3	6	204	1
	Number of CWR	2	5	3	1	1	11	1	1	16	11	1	2	2	1	2	1	1	2	21	1	1	2	3	1	5	3	2	3	18	1

Table 3S3: Number of priority CWR and taxa population in protected areas in West Africa (Contd)

		Oueme Superieur	Pai River	Pama	Parc National du W du Niger	Pendjari	Penessoulou	Pic de Fon	Pic de Tibe	Red Volta East	Rio Cacheu Mangroves	River Moshi	Sahel	Sainyinan	Sala	Sanga River	Sankan Biriwa (Tingi Hills)	Sapoba	Sebore	Seguela	Sewa - Waanje	Shai Hills	Sherigia	Tai- National Park	Tamou	Tchaourou	Tere	Tieme	Togo Plateau	Toui - Kilibo	Trois Rivieres
1	Cola acuminata (P. Beauv.) Schott & Endl.	1																													
2	Cola altissima Engl.																														
3	Cola angustifolia K. Schum.							1																							
4	Cola argentea Mast.																														
5	Cola attiensis Aubrev. & Pellegr.																														
6	Digitaria barbinodis Henrard																														
7	Digitaria cillaria (Retz.) Koeler			2						2		1	392																	1	
8	Digitaria fuscenscens (J. Presl) Henrard																														
9	Digitaria iburua Stapf																														
10	Dioscorea abyssinica Hochst. Ex Kunth																														
11	Dioscorea alata L.																														
12	Dioscorea baya De Wild.																														
13	Dioscorea bulbifera L.																														

14	Dioscorea burkilliana J. Miege																														
15	Dioscorea cayenensis Lam.	3				4																				2					
16	Dioscorea minutiflora Engl.					1																		3							
17	Dioscorea praehensilis Benth.	4				1	1						2																		
18	Dioscorea quartiniana A. Rich.					1																									
19	Dioscorea sagittifolia Pax																													1	6
20	Dioscorea sagittifolia var. lecardii (De Wild.) Nkounkou	1																													
21	Dioscorea sansibarensis Pax					4																									
22	Dioscorea schimperiana Hochst. ex Kunth					1																									
23	Dioscorea smilacifolia De Wild. & T. Durand																							3							
24	Dioscorea togoensis R. Knuth	4				22		1																							2
25	Echinochloa colonum (L.) Link																														
26	Echinochloa crus-galli (L.) P. Beauv.																														
27	Echinochloa crus-pavonis (Kunth) Schult																														
28	Echinochloa frumentacea Link																														
29	Echinochloa pyramidalis (Lam.) Hitchc. & Chase				9	8				1	1		4				1														
30	Eleusine africana Kenn - O'Byme												2																		
31	Eleusine coracana subsp. coracana (L.) Gaertn.																														

32	Eleusine indica (L.) Gaertn.	2		1	5	13	2	1		2			5					1													
33	Eragrostis japonica (Thunb.) Trin.												10																		
34	Eragrostis pilosa (L.) P. Beauv.				2	3							206																		
35	Eragrostis prolifera (Sw.) Steud.																														
36	Eragrotis unioloides (Retz.) Nees ex Steud.							1																							
37	Gossypium anomalum Wawra												3																		
38	Gossypium barbadense Linn.		1																												
39	Gossypium herbaceum var. acerifolium (Guill. & Perr.) A. Chev.																														
40	Hordeum bulbosum L																														
41	Hordeum vulgare subsp. Spontaneum L.																														
42	Ipomoea acanthocarpa (Choisy) Hochst. ex Schweinf. & Asch.					5																									
43	Ipomoea alba L.					8																									
44	Ipomoea aquatica Forssk.	2			8	12						1	17												6						
45	Ipomoea argentaurata Hallier f.	3		1		46	2					1				1												1		2	2
46	Ipomoea asarifolia (Desr.) Roem. & Schult.	1											9																		
47	Ipomoea barteri Baker	2				1																									1
48	Ipomoea blepharophylla Hallier f.				1																										

49	Ipomoea chrysochaetia Hallier f.																														
50	Ipomoea coptica (L.) Roth ex Roem. & Schult.				6								14												1						
51	Ipomoea intrapilosa Rose																														
52	Ipomoea ochracea (Lindl.) Sweet																														
53	Ipomoea prismatosyphon Welw.																														
54	Ipomoea rubens Choisy				2								8																		
55	Manihot carthagenesis (Jacq.) Mull. Arg.																														
56	Manihot carthagenesis subsp. glaziovii (Mull. Arg.) Allem						1																								
57	Manihot dichotoma Ule																														
58	Manihot esculenta subsp. flabellifolia Crantz																														
59	Manihot esculenta subsp. peruviana Crantz																														
60	Oryza barthi A. Chev.	1			8	12			1				18								1										
61	Oryza brachyantha A. Chev. & Roeehr.				4																				6						
62	Oryza eichingeri Peter																														
63	Oryza glaberrima Steud.				1	2								3	1				1				3								
64	Oryza longistaminata A. Chev. & Roehr.				28	11			1				17												6						
65	Oryza puntata Kotschy ex Steud.				3																										
66	Panicum comorense Mez																														

67	Panicum repens L.				3	6							1																		
68	Phaseolus lunatus Linn																														
69	Phaseolus vulgaris subsp. abarigineus L.																														
70	Phaseolus vulgaris var. abarigineus L.																														
71	Phoenix reclinata Jacq.	2				1	11																			3	2				27
72	Saccharum spontaneum subsp. aegyptiacum (Willd.) Hack.																														
73	Saccharum spontaneum subsp. spontaneum L.																														
74	Sorghum bicolor subsp. Verticilliflorum (L.) Moench																														
75	Sorghum drummodii (Neee ex A. Rich.) Millsp. & Chase																														
76	Sorghum purpurreosericeum (Hoch. Ex A. Rich) Schweinf. & Asch.																														
77	Sorghum virgatum (Hack.) Stapf																														
78	Triticum turgidum L.																														
79	Triticum turgidum subsp. durum (Desf.) Husn.																														
80	Vigna ambacensis Welw. ex Bak.	1		6		2																1									
81	Vigna desmodiodes Wilczek																														

82	Vigna filicaulis Hepper	2		2		10																1				3					
83	Vigna gracilis (Guill. & Perr.) Hook. f.					4			1											1				1		1					
84	Vigna luteola (Jacq.) Benth.	2				2																									
85	Vigna macrorrhyncha (Harms) Milne - Redhead																														
86	Vigna marina (Burm.) Merill	2																													
87	Vigna multinervis Hutch. & Dalz.						1																						1		
88	Vigna nigritia Hook. f.					3		1																							
89	Vigna oblongifolia A. Rich.																														
90	Vigna racemosa (G. Don) Hutch. & Dalz.	11		2	2	41	2		1																1	1					2
91	Vigna reticulata Hook. f.	5		1	2	10																									2
92	Vigna unguiculata subsp. aduensis (L.) Pasquet																														
93	Vigna unguiculata subsp. alba (G.Don) Pasquet																														
94	Vigna unguiculata subsp. baoulensis (A.Chev.) Pasquet						2																							1	
95	Vigna unguiculata subsp. burundiensis Pasquet																														
96	Vigna unguiculata subsp. dekindtiana (Harms) Verdc.							1																							
97	Vigna unguiculata subsp. letouzeyi Pasquet																														

98	Vigna unguiculata subsp. pawekiae Pasquet																														
99	Vigna unguiculata subsp. pubescens (R.Wilczek) Pasquet																														
100	Vigna unguiculata subsp. stenophylla (Harv.) Marechal & al.																														
101	Vigna unguiculata subsp. tenuis (E.Mey) Marechal & al.																														
102	Vigna unguiculata subsp. unguiculata var. spontanea (Schweinf.) Pasquet					5																								2	
	Total number of occurrence records	49	1	15	84	239	22	6	4	5	1	3	708	3	1	1	1	1	1	1	1	2	3	7	20	11	2	1	1	7	42
	Number of CWR	18	1	7	15	28	8	6	4	3	1	3	15	1	1	1	1	1	1	1	1	2	1	3	5	5	1	1	1	5	7

Table 3S3: Number of priority CWR and taxa population in protected areas in West Africa (Contd)

		W (Benin)	W du Burkina Faso	Wara Wara Hills	Wasaini	Wawagi	Western Area	Wetland of the W of Niger National Park	Wiaga Kandema	Yankari
1	Cola acuminata (P. Beauv.) Schott & Endl.									
2	Cola altissima Engl.									
3	Cola angustifolia K. Schum.									
4	Cola argentea Mast.									
5	Cola attiensis Aubrev. & Pellegr.									
6	Digitaria barbinodis Henrard									
7	Digitaria cillaria (Retz.) Koeler								1	2
8	Digitaria fuscenscens (J. Presl) Henrard									
9	Digitaria iburua Stapf									
10	Dioscorea abyssinica Hochst. Ex Kunth									
11	Dioscorea alata L.									
12	Dioscorea baya De Wild.									
13	Dioscorea bulbifera L.									
14	Dioscorea burkilliana J. Miege									

15	Dioscorea cayenensis Lam.									
16	Dioscorea minutiflora Engl.									
17	Dioscorea praehensilis Benth.									
18	Dioscorea quartiniana A. Rich.									
19	Dioscorea sagittifolia Pax									
20	Dioscorea sagittifolia var. lecardii (De Wild.) Nkounkou									
21	Dioscorea sansibarensis Pax									
22	Dioscorea schimperiana Hochst. ex Kunth									
23	Dioscorea smilacifolia De Wild. & T. Durand	13	2							
24	Dioscorea togoensis R. Knuth	13	2							
25	Echinochloa colonum (L.) Link									
26	Echinochloa crus- galli (L.) P. Beauv.									
27	Echinochloa crus- pavonis (Kunth) Schult									
28	Echinochloa frumentacea Link									
29	Echinochloa pyramidalis (Lam.) Hitchc. & Chase	1						9		
30	Eleusine africana Kenn - O'Byme									
31	Eleusine coracana subsp. coracana (L.) Gaertn.									
32	Eleusine indica (L.) Gaertn.							5		
33	Eragrostis japonica (Thunb.) Trin.									
34	Eragrostis pilosa (L.) P. Beauv.							2		2
35	Eragrostis prolifera (Sw.) Steud.									
36	Eragrotis unioloides (Retz.) Nees ex Steud.									
37	Gossypium anomalum Wawra									
38	Gossypium barbadense Linn.									

39	Gossypium herbaceum var. acerifolium (Guill. & Perr.) A. Chev.									
40	Hordeum bulbosum L									
41	Hordeum vulgare subsp. Spontaneum L.									
42	Ipomoea acanthocarpa (Choisy) Hochst. ex Schweinf. & Asch.									
43	Ipomoea alba L.									
44	Ipomoea aquatica Forssk.	5	1					10	1	4
45	Ipomoea argentaurata Hallier f.	3								2
46	Ipomoea asarifolia (Desr.) Roem. & Schult.									
47	Ipomoea barteri Baker									
48	Ipomoea blepharophylla Hallier f.	3						2		
49	Ipomoea chrysochaetia Hallier f.									
50	Ipomoea coptica (L.) Roth ex Roem. & Schult.							7		
51	Ipomoea intrapilosa Rose									
52	Ipomoea ochracea (Lindl.) Sweet									
53	Ipomoea prismatosyphon Welw.									
54	Ipomoea rubens Choisy	3						5		2
55	Manihot carthagenesis (Jacq.) Mull. Arg.									
56	Manihot carthagenesis subsp. glaziovii (Mull. Arg.) Allem									
57	Manihot dichotoma Ule									
58	Manihot esculenta subsp. flabellifolia Crantz									
59	Manihot esculenta subsp. peruviana Crantz									
60	Oryza barthi A. Chev.	1			1			8		4
61	Oryza brachyantha A. Chev. & Roeehr.							5		

62	Oryza eichingeri Peter									
63	Oryza glaberrima Steud.			6	2	1		1		
64	Oryza longistaminata A. Chev. & Roehr.	8	1		1			32		2
65	Oryza puntata Kotschy ex Steud.							3		
66	Panicum comorense Mez									
67	Panicum repens L.	4						4		
68	Phaseolus lunatus Linn									
69	Phaseolus vulgaris subsp. abarigineus L.									
70	Phaseolus vulgaris var. abarigineus L.									
71	Phoenix reclinata Jacq.									
72	Saccharum spontaneum subsp. aegyptiacum (Willd.) Hack.									4
73	Saccharum spontaneum subsp. spontaneum L.									
74	Sorghum bicolor subsp. Verticilliflorum (L.) Moench									
75	Sorghum drummodii (Neee ex A. Rich.) Millsp. & Chase									
76	Sorghum purpurreosericeum (Hoch. Ex A. Rich) Schweinf. & Asch.									
77	Sorghum virgatum (Hack.) Stapf									
78	Triticum turgidum L.									
79	Triticum turgidum subsp. durum (Desf.) Husn.									
80	Vigna ambacensis Welw. ex Bak.	14	2							2
81	Vigna desmodiodes Wilczek									
82	Vigna filicaulis Hepper	21	3					1		
83	Vigna gracilis (Guill. & Perr.) Hook. f.	3					1			
84	Vigna luteola (Jacq.) Benth.									

85	Vigna macrorrhyncha (Harms) Milne - Redhead									
86	Vigna marina (Burm.) Merill									
87	Vigna multinervis Hutch. & Dalz.									
88	Vigna nigritia Hook. f.									
89	Vigna oblongifolia A. Rich.									
90	Vigna racemosa (G. Don) Hutch. & Dalz.	15	2					2		
91	Vigna reticulata Hook. f.							2		
92	Vigna unguiculata subsp. aduensis (L.) Pasquet									
93	Vigna unguiculata subsp. alba (G.Don) Pasquet									
94	Vigna unguiculata subsp. baoulensis (A.Chev.) Pasquet									
95	Vigna unguiculata subsp. burundiensis Pasquet									
96	Vigna unguiculata subsp. dekindtiana (Harms) Verdc.						1			
97	Vigna unguiculata subsp. letouzeyi Pasquet									
98	Vigna unguiculata subsp. pawekiae Pasquet						1			
99	Vigna unguiculata subsp. pubescens (R.Wilczek) Pasquet									
100	Vigna unguiculata subsp. stenophylla (Harv.) Marechal & al.									
101	Vigna unguiculata subsp. tenuis (E.Mey) Marechal & al.									
102	Vigna unguiculata subsp. unguiculata var. spontanea (Schweinf.) Pasquet									
	Total number of occurrence records	107	13	6	4	1	3	98	2	24
	Number of CWR	14	7	1	3	1	3	16	2	9

Table 3S4: Frequency of occurrence of ELC zones in and outside protected areas

Zone	Total taxa population in ELC category	Frequency in PA	Frequency outside PA	Frequency in reserve site	Number of reserve sites found	Frequency in genebanks	Percentage in genebank
1	793	15	778	NA	NA	110	13.87
2	2724	745	1979	19	7	743	27.27
3	32	8	24	1	1	8	25
4	3	3	NA	NA	NA	3	100
5	226	19	207	12	3	85	37.61
6	159	1	158	5	4	41	25.78
7	12	2	10	2	2	1	8.33
8	1606	512	1094	3	3	537	33.44
9	245	33	212	2	2	32	13.06
10	43	8	35	NA	NA	13	30.23
11	2911	516	2395	109	5	753	25.86
12	NA	NA	NA	NA	NA	NA	NA
13	209	42	167	12	2	90	43.06
14	NA	NA	NA	NA	NA	NA	NA
15	32	24	8	1	1	16	50
16	12	12	NA	NA	NA	NA	NA
17	NA	NA	NA	NA	NA	NA	NA
18	17	NA	17	NA	NA	2	11.76
19	16	1	15	NA	NA	NA	NA
20	8	0	8	1	1	3	37.5

21	4	0	4	NA	NA	1	25
22	NA	NA	NA	NA	NA	NA	NA
23	NA	NA	NA	NA	NA	NA	NA
24	NA	NA	NA	NA	NA	NA	NA

Table 3S5: Priority CWR present in reserve sites

	Reserve site	CWR found
1	Niokolo - Koba Park	Digitaria cillaria (Retz.) Koeler, Dioscorea sagittifolia Pax, Dioscorea sagittifolia var. lecardii (De Wild.) Nkounkou, Eleusine indica (L.) Gaertn., Eragrostis japonica (Thunb.) Trin., Eragrostis pilosa (L.) P. Beauv., Ipomoea aquatica Forssk., Ipomoea argentaurata Hallier f., Ipomoea barteri Baker, Ipomoea blepharophylla Hallier f., Oryza barthi A. Chev., Oryza brachyantha A. Chev. & Roeehr., Oryza glaberrima Steud., Oryza longistaminata A. Chev. & Roehr., Vigna ambacensis Welw. ex Bak., Vigna desmodiodes Wilczek, Vigna filicaulis Hepper, Vigna gracilis (Guill. & Perr.) Hook. f, Vigna nigritia Hook. f., Vigna racemosa (G. Don) Hutch. & Dalz., Vigna reticulata Hook. f.,
2	Boucle de la Pendjari	Dioscorea cayenensis Lam., Dioscorea sansibarensis Pax, Dioscorea togoensis R. Knuth, Echinochloa pyramidalis (Lam.) Hitchc. & Chase, Eleusine indica (L.) Gaertn., Ipomoea aquatica Forssk., Ipomoea argentaurata Hallier f., Ipomoea asarifolia (Desr.) Roem. & Schult., Oryza barthi A. Chev., Oryza longistaminata A. Chev. & Roehr., Panicum repens L., Vigna filicaulis Hepper, Vigna gracilis (Guill. & Perr.) Hook. f., Vigna racemosa (G. Don) Hutch. & Dalz., Vigna reticulata Hook. f., Vigna unguiculata subsp. unguiculata var. spontanea (Schweinf.) Pasquet
3	Dosso	Echinochloa pyramidalis (Lam.) Hitchc. & Chase, Ipomoea aquatica Forssk., Ipomoea asarifolia (Desr.) Roem. & Schult., Ipomoea blepharophylla Hallier f., Ipomoea coptica (L.) Roth ex Roem. & Schult., Ipomoea rubens Choisy, Oryza longistaminata A. Chev. & Roehr., Vigna ambacensis Welw. ex Bak., Vigna filicaulis Hepper, Vigna racemosa (G. Don) Hutch. & Dalz., Vigna reticulata Hook. f., Vigna unguiculata subsp. dekindtiana (Harms) Verdc., Vigna unguiculata subsp. unguiculata var. spontanea (Schweinf.) Pasquet
4	Mount Nimba	Cola angustifolia K. Schum., Dioscorea minutiflora Engl., Dioscorea togoensis R. Knuth, Eleusine indica (L.) Gaertn., Ipomoea asarifolia (Desr.) Roem. & Schult., Oryza barthi A. Chev., Vigna desmodiodes Wilczek, Vigna gracilis (Guill. & Perr.) Hook. f., Vigna multinervis Hutch. & Dalz., Vigna nigritia Hook. f., Vigna racemosa (G. Don) Hutch. & Dalz.
5	Yankari	Digitaria cillaria (Retz.) Koeler, Eragrostis pilosa (L.) P. Beauv., Ipomoea aquatica Forssk., Ipomoea argentaurata Hallier f., Ipomoea rubens Choisy, Oryza barthi A. Chev., Oryza longistaminata A. Chev. & Roehr., Saccharum spontaneum subsp. aegyptiacum (Willd.) Hack., Vigna ambacensis Welw. ex Bak.

6	Diecke	Cola altissima Engl., Dioscorea praehensilis Benth.
7	Nasarawa	Digitaria iburua Stapf,
8	Eto	Dioscorea cayenensis Lam.
9	Goudi	Eleusine indica (L.) Gaertn.
10	Eleiyele	-
11	Volta River	-

Table 3S6: Taxa used for species distribution modelling and criteria for predicted distribution areas in West Africa

	Taxon	Number of occurrence records	ATAUC	STAUC	Threshold	Number of pixels with STAUC > 0	Number of pixels with STAUC < 0	ASD15 (%)	Valid	Remark
1	Cola acuminata (P. Beauv.) Schott & Endl.	110	0.975	0.018	0.0481	3232	697550	0.4633	Yes	SDM
2	Cola altissima Engl.	NA	NA	NA	NA	NA	NA	NA	NA	NA
3	Cola angustifolia K. Schum.	13	0.998	0.002	0.4395	1943	698839	0.278	Yes	SDM
4	Cola argentea Mast.	NA	NA	NA	NA	NA	NA	NA	NA	NA
5	Cola attiensis Aubrev. & Pellegr.	25	0.977	0.017	0.196	4081	696701	0.5857	Yes	SDM
6	Digitaria barbinodis Henrard	10	0.868	0.173	0.8971	169053	531729	31.793	No	SDM
7	Digitaria cillaria (Retz.) Koeler	960	0.926	0.015	0.2564	34751	666031	5.2176	Yes	SDM
8	Digitaria fuscenscens (J. Presl) Henrard	34	0.949	0.03	0.1248	4753	696029	0.6828	Yes	SDM
9	Digitaria iburua Stapf	10	0.916	0.081	0.4019	73509	627273	11.7188	Yes	SDM
10	Dioscorea abyssinica Hochst. Ex Kunth	1	NA	NA	NA	NA	NA	NA	NA	CA50
11	Dioscorea alata L.	4	NA	NA	NA	NA	NA	NA	NA	CA50
12	Dioscorea baya De Wild.	2	NA	NA	NA	NA	NA	NA	NA	CA50
13	Dioscorea bulbifera L.	9	0.964	0.02	0.7164	34749	666033	5.2173	Yes	CA50
14	Dioscorea burkilliana J. Miege	97	0.973	0.023	0.1472	10373	690409	1.5024	Yes	SDM

15	Dioscorea cayenensis Lam.	246	0.962	0.014	0.1558	19214	681568	2.819	Yes	SDM
16	Dioscorea minutiflora Engl.	208	0.972	0.019	0.1665	12885	687897	1.8731	Yes	SDM
17	Dioscorea praehensilis Benth.	425	0.953	0.013	0.2167	21516	679266	3.1675	Yes	SDM
18	Dioscorea quartiniana A. Rich.	42	0.953	0.027	0.2941	1943	698839	0.278	Yes	SDM
19	Dioscorea sagittifolia Pax	188	0.988	0.004	0.2722	9384	691400	1.3572	Yes	SDM
20	Dioscorea sagittifolia var. lecardii (De Wild.) Nkounkou	28	0.905	0.054	0.5197	45738	655044	6.9824	Yes	SDM
21	Dioscorea sansibarensis Pax	51	0.958	0.043	0.1071	11534	689248	1.6734	Yes	SDM
22	Dioscorea schimperiana Hochst. ex Kunth	7	0.733	0.185	0.5	140631	560151	25.1059	No	CA50
23	Dioscorea smilacifolia De Wild. & T. Durand	217	0.973	0.01	0.1989	15025	685757	2.1908	Yes	SDM
24	Dioscorea togoensis R. Knuth	474	0.969	0.01	0.1834	13144	687638	1.9114	Yes	SDM
25	Echinochloa colonum (L.) Link	NA	NA	NA	NA	NA	NA	NA	NA	NA
26	Echinochloa crus- galli (L.) P. Beauv.	5	0.943	0.039	0.6875	56471	644311	8.7645	Yes	CA50
27	Echinochloa crus- pavonis (Kunth) Schult	NA	NA	NA	NA	NA	NA	NA	NA	NA
28	Echinochloa frumentacea Link	NA	NA	NA	NA	NA	NA	NA	NA	NA
29	Echinochloa pyramidalis (Lam.) Hitchc. & Chase	656	0.939	0.015	0.1551	30311	670471	4.5208	Yes	SDM
30	Eleusine africana Kenn - O'Byme	30	0.876	0.104	0.4231	31898	668884	4.7688	Yes	SDM
31	Eleusine coracana subsp. coracana (L.) Gaertn.	NA	NA	NA	NA	NA	NA	NA	NA	NA
32	Eleusine indica (L.) Gaertn.	674	0.922	0.01	0.2739	52504	648278	8.0989	Yes	SDM
33	Eragrostis japonica (Thunb.) Trin.	176	0.922	0.031	0.2047	51154	649628	7.8743	Yes	SDM
34	Eragrostis pilosa (L.) P. Beauv.	774	0.935	0.012	0.1711	28928	671854	4.3056	Yes	SDM
35	Eragrostis prolifera (Sw.) Steud.	NA	NA	NA	NA	NA	NA	NA	NA	NA
36	Eragrotis unioloides (Retz.) Nees ex Steud.	19	0.987	0.011	0.053	7376	693406	1.0637	Yes	SDM
37	Gossypium anomalum Wawra	35	0.957	0.034	0.1785	19356	681426	2.84051	Yes	SDM
38	Gossypium barbadense Linn.	17	0.917	0.106	0.1367	19848	680934	2.9148	Yes	SDM
39	Gossypium herbaceum var. acerifolium (Guill. & Perr.) A. Chev.	8	0.719	0.083	0.7014	245783	454999	54.0183	Yes	CA50
40	Hordeum bulbosum L	NA	NA	NA	NA	NA	NA	NA	NA	NA
41	Hordeum vulgare subsp. Spontaneum L.	NA	NA	NA	NA	NA	NA	NA	NA	NA
42	Ipomoea acanthocarpa (Choisy) Hochst. ex Schweinf. & Asch.	24	0.923	0.046	0.3756	37641	663141	5.6761	Yes	SDM
43	Ipomoea alba L.	62	0.925	0.074	0.2408	15450	685332	2.2543	Yes	SDM

44	Ipomoea aquatica Forssk.	679	0.931	0.013	0.2091	38428	662354	5.8017	Yes	SDM
45	Ipomoea argentaurata Hallier f.	434	0.957	0.008	0.1942	26834	673948	3.9816	Yes	SDM
46	Ipomoea asarifolia (Desr.) Roem. & Schult.	265	0.941	0.014	0.2177	32654	668128	4.8873	Yes	SDM
47	Ipomoea barteri Baker	61	0.974	0.027	0.5225	3322	697460	0.4762	Yes	SDM
48	Ipomoea blepharophylla Hallier f.	45	0.941	0.014	0.3337	34683	666099	5.2068	Yes	SDM
49	Ipomoea chrysochaetia Hallier f.	13	0.909	0.048	0.4072	79275	621507	12.7552	No	SDM
50	Ipomoea coptica (L.) Roth ex Roem. & Schult.	137	0.96	0.01	0.1581	14509	686273	2.1141	Yes	SDM
51	Ipomoea intrapilosa Rose	NA	NA	NA	NA	NA	NA	NA	NA	NA
52	Ipomoea ochracea (Lindl.) Sweet	6	NA	NA	NA	NA	NA	NA	NA	CA50
53	Ipomoea prismatosyphon Welw.	NA	NA	NA	NA	NA	NA	NA	NA	NA
54	Ipomoea rubens Choisy	93	0.977	0.024	0.2103	8407	692375	1.2142	Yes	SDM
55	Manihot carthagenesis (Jacq.) Mull. Arg.	NA	NA	NA	NA	NA	NA	NA	NA	NA
56	Manihot carthagenesis subsp. glaziovii (Mull. Arg.) Allem	24	0.93	0.067	0.3619	6304	694478	0.9077	Yes	SDM
57	Manihot dichotoma Ule	1	NA	NA	NA	NA	NA	NA	NA	CA50
58	Manihot esculenta subsp. flabellifolia Crantz	NA	NA	NA	NA	NA	NA	NA	NA	NA
59	Manihot esculenta subsp. peruviana Crantz	NA	NA	NA	NA	NA	NA	NA	NA	NA
60	Oryza barthi A. Chev.	2396	0.927	0.008	0.189	46254	654528	7.0667	Yes	SDM
61	Oryza brachyantha A. Chev. & Roeehr.	93	0.936	0.056	0.2354	27678	673104	4.1119	Yes	SDM
62	Oryza eichingeri Peter	9	0.955	0.065	0.7222	27945	672837	4.1533	Yes	CA50
63	Oryza glaberrima Steud.	3594	0.896	0.004	0.2912	67381	633401	10.6379	No	SDM
64	Oryza longistaminata A. Chev. & Roehr.	1030	0.924	0.009	0.1973	54295	646487	8.3984	Yes	SDM
56	Oryza puntata Kotschy ex Steud.	78	0.941	0.32	0.2173	20072	680710	2.9486	Yes	SDM
66	Panicum comorense Mez	15	0.935	0.079	0.2788	31734	669048	4.7431	Yes	SDM
67	Panicum repens L.	400	0.951	0.011	0.1438	15447	685335	2.2539	Yes	SDM
68	Phaseolus lunatus Linn	NA	NA	NA	NA	NA	NA	NA	NA	NA
69	Phaseolus vulgaris subsp. abarigineus L.	NA	NA	NA	NA	NA	NA	NA	NA	NA
70	Phaseolus vulgaris var. abarigineus L.	NA	NA	NA	NA	NA	NA	NA	NA	NA
71	Phoenix reclinata Jacq.	333	0.966	0.011	0.2172	13722	687060	1.9972	Yes	SDM
72	Saccharum spontaneum subsp. aegyptiacum (Willd.) Hack.	4	0.958	0.051	0.8875	11970	688812	1.7377	Yes	CA50

73	Saccharum spontaneum subsp. spontaneum L.	NA	NA	NA	NA	NA	NA	NA	NA	NA
74	Sorghum bicolor subsp. Verticilliflorum (L.) Moench	NA	NA	NA	NA	NA	NA	NA	NA	NA
75	Sorghum drummodii (Neee ex A. Rich.) Millsp. & Chase	5	0.965	0.027	0.6176	43309	657473	6.5871	Yes	CA50
76	Sorghum purpurreosericeum (Hoch. Ex A. Rich) Schweinf. & Asch.	3	0.961	0.026	0.92	14881	685901	2.16955	Yes	CA50
77	Sorghum virgatum (Hack.) Stapf	NA	NA	NA	NA	NA	NA	NA	NA	NA
78	Triticum turgidum L.	2	NA	NA	NA	NA	NA	NA	NA	CA50
79	Triticum turgidum subsp. durum (Desf.) Husn.	NA	NA	NA	NA	NA	NA	NA	NA	NA
80	Vigna ambacensis Welw. ex Bak.	574	0.938	0.017	0.2418	44345	656437	6.7554	Yes	SDM
81	Vigna desmodiodes Wilczek	17	0.856	0.067	0.4867	150967	549815	27.4577	No	SDM
82	Vigna filicaulis Hepper	399	0.957	0.012	0.186	30353	670429	4.5273	Yes	SDM
83	Vigna gracilis (Guill. & Perr.) Hook. f.	544	0.947	0.011	0.1881	27151	673631	4.0305	Yes	SDM
84	Vigna luteola (Jacq.) Benth.	229	0.96	0.021	0.152	11231	689551	1.6287	Yes	SDM
85	Vigna macrorrhyncha (Harms) Milne - Redhead	NA	NA	NA	NA	NA	NA	NA	NA	NA
86	Vigna marina (Burm.) Merill	40	0.963	0.029	0.0799	12433	688349	1.8062	Yes	SDM
87	Vigna multinervis Hutch. & Dalz.	176	0.966	0.014	0.1546	13072	687708	1.9008	Yes	SDM
88	Vigna nigritia Hook. f.	244	0.942	0.033	0.1516	13121	687661	1.908	Yes	SDM
89	Vigna oblongifolia A. Rich.	167	0.948	0.089	0.0042	1111	699671	0.1587	Yes	SDM
90	Vigna racemosa (G. Don) Hutch. & Dalz.	1352	0.936	0.008	0.2736	42386	658396	6.4377	Yes	SDM
91	Vigna reticulata Hook. f.	578	0.949	0.013	0.1991	34469	666313	5.173	Yes	SDM
92	Vigna unguiculata subsp. aduensis (L.) Pasquet	NA	NA	NA	NA	NA	NA	NA	NA	NA
93	Vigna unguiculata subsp. alba (G.Don) Pasquet	NA	NA	NA	NA	NA	NA	NA	NA	NA
94	Vigna unguiculata subsp. baoulensis (A.Chev.) Pasquet	39	0.953	0.027	0.382	17413	683369	2.5481	Yes	SDM
95	Vigna unguiculata subsp. burundiensis Pasquet	NA	NA	NA	NA	NA	NA	NA	NA	NA
96	Vigna unguiculata subsp. dekindtiana (Harms) Verdc.	333	0.94	0.016	0.21193	29812	670970	4.4431	Yes	SDM
97	Vigna unguiculata subsp. letouzeyi Pasquet	6	0.974	0.038	0.2645	32307	668475	4.8329	Yes	CA50
98	Vigna unguiculata subsp. pawekiae Pasquet	2	NA	NA	NA	NA	NA	NA	NA	CA50
99	Vigna unguiculata subsp. pubescens (R.Wilczek) Pasquet	2	NA	NA	NA	NA	NA	NA	NA	CA50
100	Vigna unguiculata subsp. stenophylla (Harv.) Marechal & al.	13	0.906	0.042	0.3613	62843	637939	9.8509	Yes	SDM
101	Vigna unguiculata subsp. tenuis (E.Mey) Marechal & al.	NA	NA	NA	NA	NA	NA	NA	NA	NA

102	Vigna unguiculata subsp. unguiculata var. spontanea (Schweinf.) Pasquet	49	0.943	0.023	0.2189	22318	678464	3.2894	Yes	SDM

Table 3S7: Selected ecogeographic variables used in MaxEnt

	Taxon	**Bioclimatic variables**																
1	Cola acuminata (P. Beauv.) Schott & Endl.	bio_1	bio_4	bio_5	bio_7	bio_8	bio_10	bio_11	bio_12	bio_15	bio_16	bio_19	-	-	-	-	-	-
2	Cola altissima Engl.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3	Cola angustifolia K. Schum.	bio_1	bio_3	bio_4	bio_7	bio_12	bio_15	bio_16	bio_18	bio_19	-	-	-	-	-	-	-	-
4	Cola argentea Mast.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5	Cola attiensis Aubrev. & Pellegr.	bio_1	bio_4	bio_5	bio_7	bio_8	bio_10	bio_11	bio_12	bio_15	bio_16	bio_19	-	-	-	-	-	-
6	Digitaria barbinodis Henrard	bio_6	bio_9	bio_12	bio_13	bio_14	bio_16						-	-	-	-	-	-
7	Digitaria cillaria (Retz.) Koeler	bio_1	bio_3	bio_4	bio_5	bio_7	bio_10	bio_11	bio_12	bio_15	bio_16	bio_18	bio_19					
8	Digitaria fuscenscens (J. Presl) Henrard	bio_1	bio_3	bio_4	bio_7	bio_12	bio_15	bio_18	bio_19	-	-	-	-	-	-	-	-	-
9	Digitaria iburua Stapf	bio_1	bio_3	bio_4	bio_5	bio_6	bio_7	bio_9	bio_10	bio_11	bio_12	bio_14	bio_15	bio_16	bio_17	bio_18	bio_19	
10	Dioscorea abyssinica Hochst. Ex Kunth	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11	Dioscorea alata L.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12	Dioscorea baya De Wild.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13	Dioscorea bulbifera L.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
14	Dioscorea burkilliana J. Miege	bio_1	bio_3	bio_4	bio_6	bio_7	bio_12	bio_14	bio_18	bio_19	-	-	-	-	-	-	-	-
15	Dioscorea cayenensis Lam.	bio_1	bio_2	bio_3	bio_4	bio_5	bio_6	bio_7	bio_8	bio_12	bio_13	bio_14	bio_15	bio_16	bio_17	bio_18	bio_19	-
16	Dioscorea minutiflora Engl.	bio_1	bio_2	bio_3	bio_4	bio_5	bio_6	bio_7	bio_8	bio_12	bio_13	bio_14	bio_17	bio_18	bio_19	-	-	-
17	Dioscorea praehensilis Benth.	bio_1	bio_2	bio_3	bio_4	bio_5	bio_6	bio_7	bio_8	bio_12	bio_13	bio_14	bio_17	bio_18	bio_19	-	-	-
18	Dioscorea quartiniana A. Rich.	bio_1	bio_2	bio_3	bio_4	bio_5	bio_6	bio_7	bio_8	bio_12	bio_13	bio_14	bio_15	bio_18	bio_19	-	-	-
19	Dioscorea sagittifolia Pax	bio_1	bio_2	bio_3	bio_4	bio_6	bio_12	bio_13	bio_14	bio_15	bio_18	bio_19	-	-	-	-	-	-

20	Dioscorea sagittifolia var. lecardii (De Wild.) Nkounkou	bio_1	bio_2	bio_3	bio_4	bio_6	bio_12	bio_13	bio_14	bio_15	bio_18	bio_19	-	-	-	-	-	-
21	Dioscorea sansibarensis Pax	bio_1	bio_2	bio_3	bio_4	bio_6	bio_8	bio_10	bio_11	bio_12	bio_13	bio_14	bio_15	bio_16	bio_17	bio_18	bio_19	-
22	Dioscorea schimperiana Hochst. ex Kunth	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
23	Dioscorea smilacifolia De Wild. & T. Durand	bio_1	bio_2	bio_3	bio_4	bio_6	bio_8	bio_10	bio_11	bio_12	bio_14	bio_15	bio_16	bio_17	bio_18	bio_19	-	-
24	Dioscorea togoensis R. Knuth	bio_1	bio_2	bio_3	bio_4	bio_6	bio_8	bio_10	bio_11	bio_12	bio_13	bio_14	bio_15	bio_16	bio_17	bio_18	bio_19	-
25	Echinochloa colonum (L.) Link	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
26	Echinochloa crus- galli (L.) P. Beauv.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
27	Echinochloa crus- pavonis (Kunth) Schult	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
28	Echinochloa frumentacea Link	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
29	Echinochloa pyramidalis (Lam.) Hitchc. & Chase	bio_1	bio_2	bio_3	bio_4	bio_6	bio_10	bio_11	bio_12	bio_14	bio_15	bio_16	bio_17	bio_18	bio_19	-	-	-
30	Eleusine africana Kenn - O'Byme	bio_1	bio_3	bio_6	bio_11	bio_12	bio_14	bio_16	bio_17	bio_18	bio_19		-	-	-	-	-	-
31	Eleusine coracana subsp. coracana (L.) Gaertn.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
32	Eleusine indica (L.) Gaertn.	bio_1	bio_2	bio_3	bio_4	bio_6	bio_10	bio_11	bio_12	bio_14	bio_15	bio_16	bio_17	bio_18	bio_19	-	-	-
33	Eragrostis japonica (Thunb.) Trin.	bio_1	bio_2	bio_3	bio_4	bio_6	bio_7	bio_9	bio_10	bio_11	bio_12	bio_14	bio_15	bio_16	bio_17	bio_18	bio_19	
34	Eragrostis pilosa (L.) P. Beauv.	bio_1	bio_2	bio_3	bio_4	bio_6	bio_7	bio_9	bio_10	bio_11	bio_12	bio_13	bio_14	bio_15	bio_16	bio_17	bio_18	bio_19
35	Eragrostis prolifera (Sw.) Steud.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
36	Eragrotis unioloides (Retz.) Nees ex Steud.	bio_2	bio_3	bio_4	bio_12	bio_13	bio_14	bio_17	bio_19	-	-	-	-	-	-	-	-	-
37	Gossypium anomalum Wawra	bio_1	bio_2	bio_6	bio_7	bio_8	bio_9	bio_12	bio_13	bio_14	bio_15	bio_16	bio_17	bio_18	bio_19	-	-	-
38	Gossypium barbadense Linn.	bio_1	bio_6	bio_7	bio_8	bio_9	bio_11	bio_13	bio_15	bio_18	-	-	-	-	-	-	-	-
39	Gossypium herbaceum var. acerifolium (Guill. & Perr.) A. Chev.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
40	Hordeum bulbosum L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
41	Hordeum vulgare subsp. Spontaneum L.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

42	Ipomoea acanthocarpa (Choisy) Hochst. ex Schweinf. & Asch.	bio_1	bio_4	bio_6	bio_7	bio_9	bio_11	bio_14	bio_16	bio_17	bio_18	bio_19	-	-	-	-	-	-
43	Ipomoea alba L.	bio_1	bio_4	bio_6	bio_7	bio_9	bio_11	bio_12	bio_13	bio_14	bio_15	bio_16	bio_18	bio_19	-	-	-	-
44	Ipomoea aquatica Forssk.	bio_1	bio_2	bio_3	bio_4	bio_5	bio_6	bio_7	bio_8	bio_9	bio_10	bio_11	bio_12	bio_13	bio_14	bio_15	bio_16	bio_17
45	Ipomoea argentaurata Hallier f.	bio_1	bio_2	bio_3	bio_4	bio_6	bio_8	bio_9	bio_10	bio_11	bio_12	bio_13	bio_14	bio_15	bio_16	bio_17	bio_18	bio_19
46	Ipomoea asarifolia (Desr.) Roem. & Schult.	bio_1	bio_3	bio_4	bio_6	bio_7	bio_9	bio_11	bio_12	bio_13	bio_14	bio_15	bio_16	bio_17	bio_18	bio_19	-	-
47	Ipomoea barteri Baker	bio_1	bio_3	bio_6	bio_11	bio_12	bio_14	bio_16	bio_17	bio_19	-	-	-	-	-	-	-	-
48	Ipomoea blepharophylla Hallier f.	bio_1	bio_4	bio_7	bio_11	bio_12	bio_14	bio_17	bio_18	bio_19	-	-	-	-	-	-	-	-
49	Ipomoea chrysochaetia Hallier f.	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-
50	Ipomoea coptica (L.) Roth ex Roem. & Schult.	bio_1	bio_4	bio_5	bio_6	bio_11	bio_12	bio_13	bio_14	bio_15	bio_16	bio_17	bio_18	bio_19	-	-	-	-
51	Ipomoea intrapilosa Rose	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
52	Ipomoea ochracea (Lindl.) Sweet	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
53	Ipomoea prismatosyphon Welw.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
54	Ipomoea rubens Choisy	bio_1	bio_3	bio_5	bio_6	bio_7	bio_11	bio_14	bio_15	bio_16	bio_18	bio_19	-	-	-	-	-	-
55	Manihot carthagenesis (Jacq.) Mull. Arg.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
56	Manihot carthagenesis subsp. glaziovii (Mull. Arg.) Allem	bio_1	bio_4	bio_6	bio_11	bio_14	bio_17	bio_19					-	-	-	-	-	-
57	Manihot dichotoma Ule	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
58	Manihot esculenta subsp. flabellifolia Crantz	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
59	Manihot esculenta subsp. peruviana Crantz	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
60	Oryza barthi A. Chev.	bio_1	bio_4	bio_5	bio_6	bio_7	bio_10	bio_11	bio_12	bio_13	bio_14	bio_15	bio_16	bio_17	bio_18	-	-	-
61	Oryza brachyantha A. Chev. & Roeehr.	bio_1	bio_6	bio_7	bio_11	bio_12	bio_13	bio_14	bio_15	bio_16	bio_17	bio_18	bio_19	-	-	-	-	-
62	Oryza eichingeri Peter	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
63	Oryza glaberrima Steud.	bio_1	bio_3	bio_4	bio_5	bio_6	bio_7	bio_9	bio_10	bio_11	bio_12	bio_13	bio_14	bio_15	bio_16	bio_17	bio_18	bio_19
64	Oryza longistaminata A. Chev. & Roehr.	bio_1	bio_3	bio_4	bio_5	bio_6	bio_7	bio_9	bio_10	bio_11	bio_12	bio_13	bio_14	bio_15	bio_16	bio_17	bio_18	bio_19

65	Oryza puntata Kotschy ex Steud.	bio_1	bio_3	bio_4	bio_6	bio_7	bio_10	bio_12	bio_13	bio_14	bio_16	bio_17	bio_18	bio_19	-	-	-	-
66	Panicum comorense Mez	bio_1	bio_4	bio_6	bio_9	bio_13	bio_14	bio_18	bio_19				-	-	-	-	-	-
67	Panicum repens L.	bio_1	bio_3	bio_4	bio_5	bio_6	bio_7	bio_9	bio_10	bio_11	bio_12	bio_13	bio_14	bio_15	bio_16	bio_17	bio_18	bio_19
68	Phaseolus lunatus Linn	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
69	Phaseolus vulgaris subsp. abarigineus L.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
70	Phaseolus vulgaris var. abarigineus L.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
71	Phoenix reclinata Jacq.	bio_1	bio_3	bio_4	bio_6	bio_7	bio_9	bio_11	bio_12	bio_13	bio_14	bio_15	bio_16	bio_17	bio_18	bio_19	-	-
72	Saccharum spontaneum subsp. aegyptiacum (Willd.) Hack.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
73	Saccharum spontaneum subsp. spontaneum L.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
74	Sorghum bicolor subsp. Verticilliflorum (L.) Moench	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
75	Sorghum drummodii (Neee ex A. Rich.) Millsp. & Chase	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
76	Sorghum purpurreosericeum (Hoch. Ex A. Rich) Schweinf. & Asch.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
77	Sorghum virgatum (Hack.) Stapf	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
78	Triticum turgidum L.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
79	Triticum turgidum subsp. durum (Desf.) Husn.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
80	Vigna ambacensis Welw. ex Bak.	bio_1	bio_3	bio_4	bio_5	bio_6	bio_7	bio_9	bio_10	bio_11	bio_12	bio_13	bio_14	bio_15	bio_16	bio_17	bio_18	bio_19
81	Vigna desmodiodes Wilczek	bio_4	bio_13	bio_14	bio_16	-	-	-	-	-	-	-	-	-	-	-	-	-
82	Vigna filicaulis Hepper	bio_4	bio_13	bio_14	bio_16	-	-	-	-	-	-	-	-	-	-	-	-	-
83	Vigna gracilis (Guill. & Perr.) Hook. f.	bio_1	bio_3	bio_4	bio_6	bio_7	bio_9	bio_10	bio_11	bio_12	bio_13	bio_14	bio_16	bio_17	bio_18	bio_19	-	-
84	Vigna luteola (Jacq.) Benth.	bio_1	bio_3	bio_4	bio_5	bio_6	bio_7	bio_10	bio_11	bio_12	bio_13	bio_14	bio_15	bio_16	bio_17	bio_18	bio_19	-
85	Vigna macrorrhyncha (Harms) Milne - Redhead	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
86	Vigna marina (Burm.) Merill	bio_1	bio_3	bio_4	bio_6	bio_7	bio_10	bio_11	bio_14	bio_17	bio_19	-	-	-	-	-	-	-
87	Vigna multinervis Hutch. & Dalz.	bio_1	bio_3	bio_4	bio_5	bio_6	bio_7	bio_9	bio_10	bio_11	bio_12	bio_13	bio_14	bio_15	bio_16	bio_17	bio_18	bio_19

88	Vigna nigritia Hook. f.	bio_1	bio_3	bio_4	bio_5	bio_6	bio_7	bio_9	bio_10	bio_11	bio_12	bio_13	bio_14	bio_15	bio_16	bio_17	bio_18	bio_19
89	Vigna oblongifolia A. Rich.	bio_1	bio_6	bio_7	bio_12	bio_14	bio_15	bio_19		-	-	-	-	-	-	-	-	-
90	Vigna racemosa (G. Don) Hutch. & Dalz.	bio_1	bio_3	bio_5	bio_6	bio_7	bio_9	bio_10	bio_11	bio_12	bio_13	bio_14	bio_15	bio_16	bio_17	bio_18	bio_19	-
91	Vigna reticulata Hook. f.	bio_1	bio_3	bio_4	bio_6	bio_7	bio_9	bio_10	bio_11	bio_12	bio_13	bio_14	bio_16	bio_17	bio_18	bio_19	-	-
92	Vigna unguiculata subsp. aduensis (L.) Pasquet	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
93	Vigna unguiculata subsp. alba (G.Don) Pasquet	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
94	Vigna unguiculata subsp. baoulensis (A.Chev.) Pasquet	bio_1	bio_3	bio_5	bio_6	bio_7	bio_12	bio_13	bio_14	bio_17	bio_19	-	-	-	-	-	-	-
95	Vigna unguiculata subsp. burundiensis Pasquet	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
96	Vigna unguiculata subsp. dekindtiana (Harms) Verdc.	bio_1	bio_3	bio_5	bio_6	bio_7	bio_10	bio_12	bio_13	bio_15	bio_16	bio_17	bio_18	bio_19	-	-	-	-
97	Vigna unguiculata subsp. letouzeyi Pasquet	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
98	Vigna unguiculata subsp. pawekiae Pasquet	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
99	Vigna unguiculata subsp. pubescens (R.Wilczek) Pasquet	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
100	Vigna unguiculata subsp. stenophylla (Harv.) Marechal & al.	bio_1	bio_4	bio_6	bio_9	bio_13	bio_14	bio_15	bio_16	bio_17	bio_18	-	-	-	-	-	-	-
101	Vigna unguiculata subsp. tenuis (E.Mey) Marechal & al.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
102	Vigna unguiculata subsp. unguiculata var. spontanea (Schweinf.) Pasquet	bio_3	bio_11	bio_12	bio_14	bio_17	bio_18	bio_19	-	-	-	-	-	-	-	-	-	-

Table 3S8: Ecogeographic variables used for the conservation gap analyses of West African priority CWR

No	Component	Variable coe	Description	Unit	Source
1	Bioclim	bio_1	Annual average temperature	°C	WorldClim

2	Bioclim	bio_2	Average daytime temperature range	°C	WorldClim
3	Bioclim	bio_3	Isothermality	°C	WorldClim
4	Bioclim	bio_4	Temperature seasonality	°C	WorldClim
5	Bioclim	bio_5	Maximum temperature for the warmest month	°C	WorldClim
6	Bioclim	bio_6	Maximum temperature for the coldest month	°C	WorldClim
7	Bioclim	bio_7	Annual temperature range	°C	WorldClim
8	Bioclim	bio_8	Average temperature for the quarter with the most precipitation	°C	WorldClim
9	Bioclim	bio_9	Average temperature for the driest quarter	°C	WorldClim
10	Bioclim	bio_10	Average temperature for the hotest quarter	°C	WorldClim
11	Bioclim	bio_11	Average temperature for the coldest quarter	°C	WorldClim
12	Bioclim	bio_12	Annual precipitation	mm	WorldClim
13	Bioclim	bio_13	Precipitation during the wettest month	mm	WorldClim
14	Bioclim	bio_14	Precipitation during the driest month	mm	WorldClim
15	Bioclim	bio_15	Seasonality of precipitation (variation coefficient)	mm	WorldClim
16	Bioclim	bio_16	Precipitation during the wettest quarter (3 rainest months)	mm	WorldClim
17	Bioclim	bio_17	Precipitation during the driest quarter (3 driest months)	mm	WorldClim
18	Bioclim	bio_18	Precipitation during the hottest quarter (3 hottest months)	mm	WorldClim
19	Bioclim	bio_19	Precipitation during the coldest quarter (3 coldest months)	mm	WorldClim
20	Edaphic	t_sand	Sand content in top soil	% weight	ISRIC
21	Edaphic	t_silt	Silt content in top soil	% weight	ISRIC
22	Edaphic	t_clay	Clay content in top soil	% weight	ISRIC
23	Edaphic	t_ref_bulk	Bulk density reference in top soil	kg/dm3	ISRIC
24	Edaphic	t_oc	Organic carbon content in top soil	% weight	ISRIC
25	Edaphic	t_cec	Cation exchange capacity in top soil	cmol/kg	ISRIC
26	Edaphic	t_phh2o	top soil pH in a soil water solution	-log(H+)	ISRIC
27	Edaphic	t_phhox	Soil Ph x 10 in H2O	-log(H+)	ISRIC
28	Edaphic	t_awc1	Available soil water capacity (volumetric fraction) for h1 top soil	ml	ISRIC
29	Edaphic	t_gravel	Gravel content of top soil	%vol	ISRIC
30	Edaphic	s_sand	Sand content in subsoil	% weight	ISRIC
31	Edaphic	s_silt	Silt content in subsoil	% weight	ISRIC
32	Edaphic	s_clay	Clay content in subsoil	% weight	ISRIC
33	Edaphic	s_ref_bulk	Bulk density reference in subsoil	kg/dm3	ISRIC
34	Edaphic	s_oc	Organic carbon content in subsoil	% weight	ISRIC
35	Edaphic	s_cec	Cation exchange capacity in subsoil	cmol/kg	ISRIC

				-log(H+)	
36	Edaphic	s_phh2o	Subsoil pH in a soil water solution	-log(H+)	ISRIC
37	Edaphic	s_phhox	Soil Ph x 10 in H2O		ISRIC
38	Edaphic	s_awc1	Available soil water capacity (volumetric fraction) for h1 subsoil	ml	ISRIC
39	Edaphic	s_gravel	Gravel content of subsoil	%vol	ISRIC
40	Geophysical	aspect	Aspect of the land	degree (°)	DEM from NASA
41	Geophysical	elev	Elevation. Height above sea level	m	WorldClim
42	Geophysical	slope	Slope of the land surface	degree (°)	DEM from NASA
43	Geophysical	srad_1	Solar radiation January	W/m2	WorldClim
44	Geophysical	srad_2	Solar radiation February	W/m2	WorldClim
45	Geophysical	srad_3	Solar radiation March	W/m2	WorldClim
46	Geophysical	srad_4	Solar radiation April	W/m2	WorldClim
47	Geophysical	srad_5	Solar radiation May	W/m2	WorldClim
48	Geophysical	srad_6	Solar radiation June	W/m2	WorldClim
49	Geophysical	srad_7	Solar radiation July	W/m2	WorldClim
50	Geophysical	srad_8	Solar radiation August	W/m2	WorldClim
51	Geophysical	srad_9	Solar radiation September	W/m2	WorldClim
52	Geophysical	srad_10	Solar radiation October	W/m2	WorldClim
53	Geophysical	srad_11	Solar radiation November	W/m2	WorldClim
54	Geophysical	srad_12	Solar radiation December	W/m2	WorldClim
55	Geophysical	srad_annual	Solar radiation annual	W/m2	WorldClim
56	Geophysical	wind_1	Wind speed January	m/s	WorldClim
57	Geophysical	wind_2	Wind speed February	m/s	WorldClim
58	Geophysical	wind_3	Wind speed March	m/s	WorldClim
59	Geophysical	wind_4	Wind speed April	m/s	WorldClim
60	Geophysical	wind_5	Wind speed May	m/s	WorldClim
61	Geophysical	wind_6	Wind speed June	m/s	WorldClim
62	Geophysical	wind_7	Wind speed July	m/s	WorldClim
63	Geophysical	wind_8	Wind speed August	m/s	WorldClim
64	Geophysical	wind_9	Wind speed September	m/s	WorldClim
65	Geophysical	wind_10	Wind speed October	m/s	WorldClim
66	Geophysical	wind_11	Wind speed November	m/s	WorldClim
67	Geophysical	wind_12	Wind speed December	m/s	WorldClim
68	Geophysical	wind_annual	Wind speed annual	m/s	WorldClim

Table 3S9: Average value of the ecogeographical variable in each ELC category from ELC map

ELC Category	bio_1 (°C)	bio_3 (mm)	bio_11 (°C)	bio_12 (mm)	bio_14 (mm)	bio_18 (mm)	t_clay (%weight)	t_gravel (%vol)	t_silt (%weight)	t_oc (%weight)	t_sand (%weight)	t_ph_hox (-log(H+))	elev (m)	slope (°)	eastness (1 if facing eastward and -1 for westward)	northness (1 if facing northward and -1 for southward)
0	263.3	69.1	247.51	2040.39	23.18	271.53	NA	NA	NA	NA	NA	NA	44.15	0.277	0.009	0.017
1	274.7	60.91	252.99	1008.03	0.73	119.98	27.35	12.1	22.52	8.14	50.48	59.29	264.6	0.315	-0	-0.072
2	289.1	56.18	247.48	387.8	0.065	71.94	15.28	4.52	5.84	3.61	72.57	61.34	262.2	0.296	-0.05	-0.276
3	286.6	53	231.66	224.39	0	53.64	17.96	24.8	32.77	3.52	69.84	70.46	259.6	0.879	0.021	-0.071
4	261.1	58.05	232.5	817.14	0.02	114.1	25.9	10.5	20.08	7.08	52.54	61.97	457.6	0.327	0.022	0.015
5	277.2	55.01	227.14	298.36	0	46.21	13.17	4.47	6.69	3.9	74.72	70.77	400.3	0.118	0.028	-0.017
6	285.9	52.02	223.24	176.6	0	35.57	9.29	23.3	34.77	2.45	83.11	76.43	424.5	0.187	0.024	-0.085
7	280.8	57.43	244.64	574.08	0.02	74.58	28.32	12.7	20.51	7.75	51.24	61.58	211.8	0.112	0.024	0.113
8	289.6	54.16	234.55	197.78	0	49.15	15.1	5.13	5.87	2.62	75.71	71.44	238.6	0.092	-0	0.027
9	289.1	53.48	230.51	149.38	0	47.86	13.51	22.3	34.37	2.24	78.17	74.38	222.2	0.145	-0	0.047
10	261.7	69.7	246.96	1683.56	13.56	278.45	29.88	11.4	22	12.1	51.6	54.18	253.7	0.399	0.001	-0.004
11	263.3	69.5	244.75	1147.75	7	194.25	18.78	26	34	5.76	67.5	62.76	316.8	0.521	0.108	0.003
12	241.6	63.48	226.42	1459.98	2.46	241.59	31.11	15.6	25.29	11.8	46.91	54.99	759.5	1.12	0.012	0.019
13	259	63	243	1534	1	269	15.88	4.15	9.8	5.9	70.05	56.68	486	0.264	-0.3	-0.44
14	261.4	65.25	241.38	1150.22	0.21	269.78	29.69	7.97	19.79	31.8	51.15	56.1	106.1	0.088	0.041	0.156
15	253.3	66.98	227.26	362.5	0	269.6	11.66	2.93	3.89	6.16	80.12	60.31	34.84	0.062	0.08	0.068
16	281.5	50.25	218.25	128.75	0	33	11.23	13.9	11.42	1.61	81.71	76.29	374.3	1.248	0.11	-0.001
17	274.6	50.83	207.09	83.25	0.11	30.05	11.23	20.1	35.86	1.48	82.21	79.27	344.9	1.371	-0.04	-0.022
18	255.4	55.76	215.44	588.67	0	96.74	26.94	7.07	12.22	7.2	52.85	65.51	402.8	0.21	0.016	-0.005
19	270.4	52.18	200.06	70.37	0	18.53	8.36	5.64	5.26	2.06	84.52	78.65	435.4	0.093	0.006	-0.008
20	261.9	47.76	178.52	34.94	0.003	15.21	5.65	21.8	36.63	1.54	89.62	79.24	580.9	0.321	0.002	-0.006
21	251.8	57.93	209.44	76.37	0	32.58	31.233	13.7	28.1	5.61	48.52	77.78	66.62	0.072	0.115	-0.068
22	279.9	48.68	199.11	44.55	0.04	20.96	8.22	1.35	2.043	1.39	87.98	79.51	320.7	0.067	0.038	0.01

23	271.2	46.99	186.5	30.05	0.01	14.89	6.87	22.3	35.99	1.31	89.74	79.28	307.2	0.128	-0	0.024

Table 3S10: International genebanks with West African accessions

	INSTNAME	INSTCODE	COUNTRY	PASSPORT DATA SOURCE
1	Africa Rice Center	CIV033	Cote d'Ivoire	https://www.genesys-pgr.org/iso3166/CIV
2	Botanic Garden Meise.	BEL014	Belgium	https://www.genesys-pgr.org/iso3166/BEL
3	Centro Internacional de Agricultura Tropical (CIAT)	COL003	Colombia	https://www.genesys-pgr.org/wiews/COL003
4	International Center for Agricultural Research in the Dry Areas (ICARDA)	SYR002	Syria	https://www.genesys-pgr.org/iso3166/SYR
5	International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)	IND002	India	https://www.genesys-pgr.org/iso3166/IND
6	International Institute of Tropical Agriculture (IITA)	NGA039	Nigeria	https://www.genesys-pgr.org/iso3166/NGA
7	International Livestock Research Institute (ILRI)	ETH013	Ethiopia	https://www.genesys-pgr.org/wiews/ETH013
8	International Maize and Wheat Improvement Center (CIMMYT)	MEX002	Mexico	https://www.genesys-pgr.org/iso3166/MEX
9	International Plant Genetic Resources Institute	ITA303	Italy	https://www.genesys-pgr.org/iso3166/ITA
10	International Potato Center (CIP)	PER001	Peru	https://www.genesys-pgr.org/iso3166/PER
11	Millennium Seed Bank Project, Seed Conservation Department, Royal Botanic Gardens, Kew (MSBKew)	GBR004	United Kingdom	https://www.genesys-pgr.org/iso3166/GBR
12	N.I. Vavilov Research Institute of Plant Industry	RUS001	Russia	https://www.genesys-pgr.org/iso3166/RUS
13	National Small Grains Germplasm Research Facility, USDA-ARS	USA029	United States	https://www.genesys-pgr.org/iso3166/USA
14	International Rice Research Institute	PHL001	Philippines	https://www.genesys-pgr.org/iso3166/PHL
15	Institute of Plant Production n.a. V.Y. Yurjev of UAAS (UAAS)	UKR001	Ukraine	https://www.genesys-pgr.org/iso3166/UKR
16	Australian Grains Genebank, Department of Environment and Primary Industries	AUS165	Australia	https://www.genesys-pgr.org/iso3166/AUS

Table 3S11: Priority CWR related crop, concept type and level

	FAMILY	TAXON	RELATED CROP	COMMON CROP NAME	CONCEPT TYPE	CONCEPT LEVEL
1	Sterculiaceae	*Cola acuminata* (P. Beauv.) Schott & Endl.	*Cola nitida*(Vent.) Schott & Endl.	Kola nut;cola;kola	Gene Pool	1B
2	Sterculiaceae	*Cola altissima* Engl.	*Cola nitida*(Vent.) Schott & Endl.	Kola nut;cola;kola	Taxon Group	4
3	Sterculiaceae	*Cola angustifolia* K. Schum.	*Cola nitida*(Vent.) Schott & Endl.	Kola nut;cola;kola	Taxon Group	4
4	Sterculiaceae	*Cola argentea* Mast.	*Cola nitida*(Vent.) Schott & Endl.	Kola nut;cola;kola	Taxon Group	4
5	Sterculiaceae	*Cola attiensis* Aubrév. & Pellegr.	*Cola nitida*(Vent.) Schott & Endl.	Kola nut;cola;kola	Taxon Group	4
6	Poaceae	*Digitaria barbinodis* Henrard	*Digitaria exilis* (Kippist) Stapf	Fonio;Hungry millet;hungry rice;acha grass	Gene Pool	3
7	Poaceae	*Digitaria ciliaris* (Retz.) Koeler	*Digitaria exilis* (Kippist) Stapf	Fonio;Hungry millet;hungry rice;acha grass	Gene Pool	2
8	Poaceae	*Digitaria fuscescens* (J.Presl) Henrard	*Digitaria exilis* (Kippist) Stapf	Fonio;Hungry millet;hungry rice;acha grass	Gene Pool	2
9	Poaceae	*Digitaria iburua* Stapf	*Digitaria exilis* (Kippist) Stapf	Fonio;Hungry millet;hungry rice;acha grass	Gene Pool	2
10	Dioscoreaceae	*Dioscorea togoensis* R.Knuth	*Dioscorea rotundata* Poir.	White yam	Gene Pool	2
11	Dioscoreaceae	*Dioscorea abyssinica* Hochst. ex Kunth	*Dioscorea rotundata* Poir.	White yam	Gene Pool	2
12	Dioscoreaceae	*Dioscorea alata* L.	*Dioscorea rotundata* Poir.	White yam	Gene Pool	2
13	Dioscoreaceae	*Dioscorea baya* De Wild.	*Dioscorea rotundata* Poir.	White yam	Gene Pool	3
14	Dioscoreaceae	*Dioscorea bulbifera* L.	*Dioscorea rotundata* Poir.	White yam	Gene Pool	2
15	Dioscoreaceae	*Dioscorea burkilliana* J.Miège	*Dioscorea rotundata* Poir.	White yam	Gene Pool	3
16	Dioscoreaceae	*Dioscorea cayenensis* Lam.	*Dioscorea rotundata* Poir.	White yam	Gene Pool	1B
17	Dioscoreaceae	*Dioscorea minutiflora* Engl.	*Dioscorea rotundata* Poir.	White yam	Gene Pool	2
18	Dioscoreaceae	*Dioscorea praehensilis* Benth.	*Dioscorea rotundata* Poir.	White yam	Gene Pool	2
19	Dioscoreaceae	*Dioscorea quartiniana* A.Rich.	*Dioscorea rotundata* Poir.	White yam	Taxon Group	4

20	Dioscoreaceae	*Dioscorea sagittifolia* Pax	*Dioscorea rotundata* Poir.	White yam	Taxon Group	4
21	Dioscoreaceae	*Dioscorea sagittifolia* var. *lecardii* (De Wild.) Nkounkou	*Dioscorea rotundata* Poir.	White yam	Gene Pool	2
22	Dioscoreaceae	*Dioscorea sansibarensis* Pax	*Dioscorea rotundata* Poir.	White yam	Taxon Group	4
23	Dioscoreaceae	*Dioscorea schimperiana* Hochst. ex Kunth	*Dioscorea rotundata* Poir.	White yam	Taxon Group	4
24	Dioscoreaceae	*Dioscorea smilacifolia* De Wild. & T.Durand	*Dioscorea rotundata* Poir.	White yam	Gene Pool	2
25	Poaceae	*Echinochloa colonum* (L.) Link	*Echinochloa esculenta* (A. Braun) H. Scholz	Barnyard millet;Japanese millet	Taxon Group	4
26	Poaceae	*Echinochloa crus-galli* (L.) P.Beauv.	*Echinochloa esculenta* (A. Braun) H. Scholz	Barnyard millet;Japanese millet	Gene Pool	1B
27	Poaceae	*Echinochloa crus-pavonis* (Kunth) Schult	*Echinochloa esculenta* (A. Braun) H. Scholz	Barnyard millet;Japanese millet	Taxon Group	4
28	Poaceae	*Echinochloa frumentacea* Link	*Echinochloa esculenta* (A. Braun) H. Scholz	Barnyard millet;Japanese millet	Gene Pool	2
29	Poaceae	*Echinochloa pyramidalis* (Lam.) Hitchc. & Chase	*Echinochloa esculenta* (A. Braun) H. Scholz	Barnyard millet;Japanese millet	Taxon Group	4
30	Poaceae	*Eleusine africana* Kenn.-O'Byrne	*Eleusine coracana* (L.) Gaertn.	Finger millet	Gene Pool	3
31	Poaceae	*Eleusine coracana* subsp. *coracana* (L.) Gaertn.	*Eleusine coracana* (L.) Gaertn.	Finger millet	Gene Pool	1B
32	Poaceae	*Eleusine indica* (L.) Gaertn.	*Eleusine coracana* (L.) Gaertn.	Finger millet	Gene Pool	2
33	Poaceae	*Eragrostis japonica* (Thunb.) Trin.	*Eragrostis tef* (Zuccagni) Trotter	Teff	Taxon Group	4
34	Poaceae	*Eragrostis pilosa* (L.) P.Beauv.	*Eragrostis tef* (Zuccagni) Trotter	Teff	Gene Pool	1B
35	Poaceae	*Eragrostis prolifera* (Sw.) Steud.	*Eragrostis tef* (Zuccagni) Trotter	Teff	Taxon Group	4
36	Poaceae	*Eragrostis unioloides* (Retz.) Nees ex Steud.	*Eragrostis tef* (Zuccagni) Trotter	Teff	Taxon Group	4
37	Malvaceae	*Gossypium anomalum* Wawra	*Gossypium hirsutum* Linn.	Upland cotton;Mexican cotton	Gene Pool	3
38	Malvaceae	*Gossypium barbadense* Linn.	*Gossypium hirsutum* Linn.	Upland cotton;Mexican cotton	Gene Pool	1B

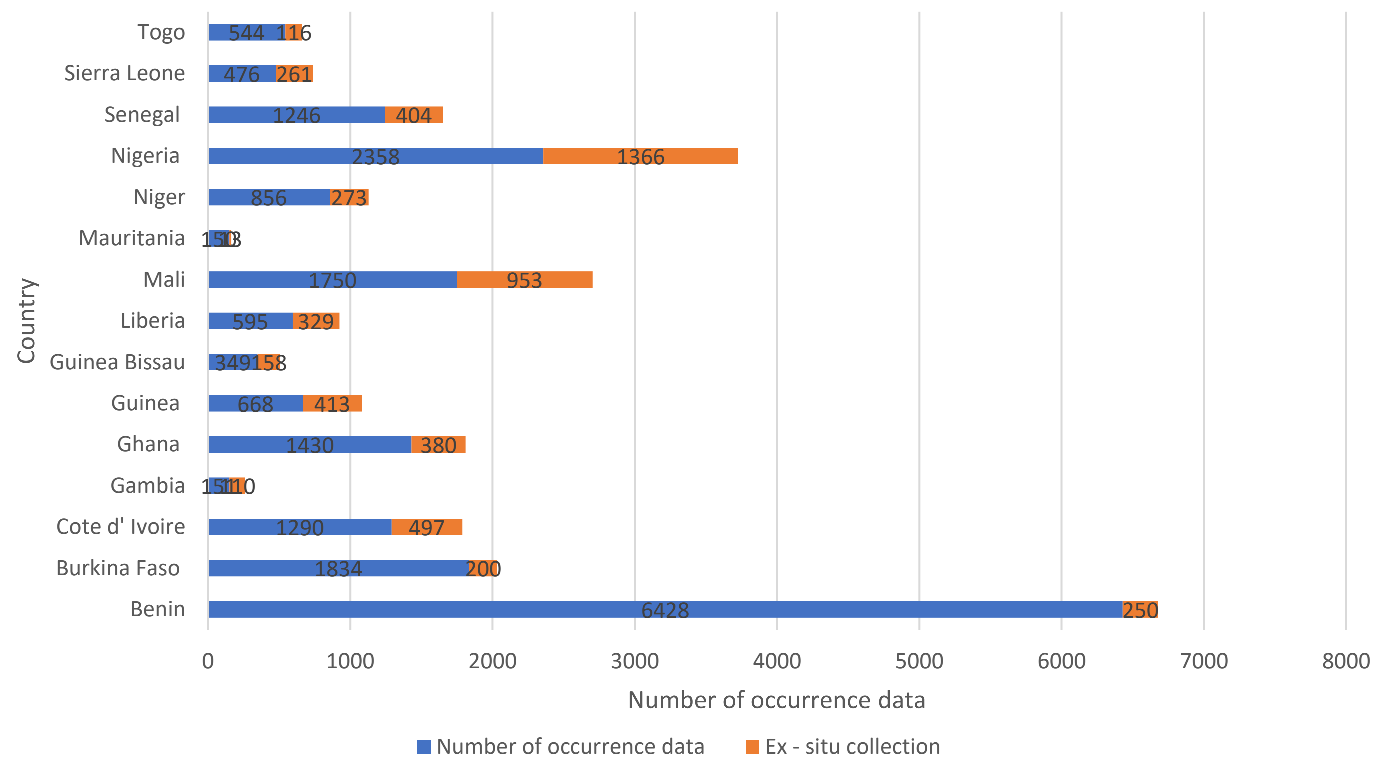
39	Malvaceae	*Gossypium herbaceum* var. *acerifolium* (Guill. & Perr.) A. Chev.	*Gossypium hirsutum* Linn.	Upland cotton;Mexican cotton	Gene Pool	3
40	Poaceae	*Hordeum bulbosum* L.	*Hordeum vulgare* L.	Common barley	Gene Pool	2
41	Poaceae	*Hordeum vulgare* subsp. *spontaneum* L.	*Hordeum vulgare* L.	Common barley	Gene Pool	1B
42	Convolvulaceae	*Ipomoea acanthocarpa* (Choisy) Hochst. ex Schweinf. & Asch.	*Ipomoea batatas* (L.) Lam.	Sweetpotato	Taxon Group	4
43	Convolvulaceae	*Ipomoea alba* L.	*Ipomoea batatas* (L.) Lam.	Sweetpotato	Taxon Group	4
44	Convolvulaceae	*Ipomoea aquatica* Forssk.	*Ipomoea batatas* (L.) Lam.	Sweetpotato	Taxon Group	4
45	Convolvulaceae	*Ipomoea argentaurata* Hallier f.	*Ipomoea batatas* (L.) Lam.	Sweetpotato	Taxon Group	4
46	Convolvulaceae	*Ipomoea asarifolia* (Desr.) Roem. & Schult.	*Ipomoea batatas* (L.) Lam.	Sweetpotato	Taxon Group	4
47	Convolvulaceae	*Ipomoea barteri* Baker	*Ipomoea batatas* (L.) Lam.	Sweetpotato	Taxon Group	4
48	Convolvulaceae	*Ipomoea blepharophylla* Hallier f.	*Ipomoea batatas* (L.) Lam.	Sweetpotato	Taxon Group	4
49	Convolvulaceae	*Ipomoea chrysochaetia* Hallier f.	*Ipomoea batatas* (L.) Lam.	Sweetpotato	Taxon Group	4
50	Convolvulaceae	*Ipomoea coptica* (L.) Roth ex Roem. & Schult.	*Ipomoea batatas* (L.) Lam.	Sweetpotato	Taxon Group	4
51	Convolvulaceae	*Ipomoea intrapilosa* Rose	*Ipomoea batatas* (L.) Lam.	Sweetpotato	Taxon Group	4
52	Convolvulaceae	*Ipomoea ochracea (Lindl.) Sweet*	*Ipomoea batatas* (L.) Lam.	Sweetpotato	Taxon Group	4
53	Convolvulaceae	*Ipomoea prismatosyphon* Welw.	*Ipomoea batatas* (L.) Lam.	Sweetpotato	Taxon Group	4
54	Convolvulaceae	*Ipomoea rubens* Choisy	*Ipomoea batatas* (L.) Lam.	Sweetpotato	Taxon Group	4
55	Euphorbiaceae	*Manihot carthagenensis* (Jacq.) Müll.Arg.	*Manihot esculenta* Crantz	cassava	Gene Pool	2
56	Euphorbiaceae	*Manihot carthagenensis* subsp. *glaziovii* (Müll.Arg.) Allem	*Manihot esculenta* Crantz	cassava	Gene Pool	2
57	Euphorbiaceae	*Manihot dichotoma* Ule	*Manihot esculenta* Crantz	cassava	Gene Pool	2
58	Euphorbiaceae	*Manihot esculenta* subsp. *flabellifolia* Crantz	*Manihot esculenta* Crantz	cassava	Gene Pool	1B

59	Euphorbiaceae	*Manihot esculenta* subsp. *peruviana* Crantz	*Manihot esculenta* Crantz	cassava	Gene Pool	3
60	Poaceae	*Oryza barthii* A.Chev.	*Oryza sativa* L.	Asian rice	Gene Pool	1B
61	Poaceae	*Oryza brachyantha* A.Chev. & Roehr.	*Oryza sativa* L.	Asian rice	Gene Pool	3
62	Poaceae	*Oryza eichingeri* Peter	*Oryza sativa* L.	Asian rice	Gene Pool	2
63	Poaceae	*Oryza glaberrima* Steud.	*Oryza sativa* L.	Asian rice	Gene Pool	1B
64	Poaceae	*Oryza longistaminata* A.Chev. & Roehr.	*Oryza sativa* L.	Asian rice	Gene Pool	1B
65	Poaceae	*Oryza punctata* Kotschy ex Steud.	*Oryza sativa* L.	Asian rice	Gene Pool	2
66	Poaceae	*Panicum comorense* Mez	*Panicum miliaceum* L.	Proso millet	Taxon Group	4
67	Poaceae	*Panicum repens* L.	*Panicum miliaceum* L.	Proso millet	Gene Pool	3
68	Papilionaceae	*Phaseolus lunatus* Linn.	*Phaseolus vulgaris* Linn.	Common bean;Kidney bean	Taxon Group	4
69	Papilionaceae	*Phaseolus vulgaris* subsp. *abarigineus* L.	*Phaseolus vulgaris* Linn.	Common bean;Kidney bean	Gene Pool	1B
70	Papilionaceae	*Phaseolus vulgaris* var *aborigineus*L.	*Phaseolus vulgaris* Linn.	Common bean;Kidney bean	Gene Pool	1B
71	Arecaceae	*Phoenix reclinata* Jacq.	*Phoenix dactylifera* L.	Date palm	Gene Pool	1B
72	Poaceae	*Saccharum spontaneum* subsp. *spontaneum* L.	*Saccharum officinarum* L.	Sugarcane;Purple Sugar Cane	Gene Pool	3
73	Poaceae	*Saccharum spontaneum* subsp. *aegyptiacum* (Willd.) Hack.	*Saccharum officinarum* L.	Sugarcane;Purple Sugar Cane	Gene Pool	2
74	Poaceae	*Sorghum bicolor* subsp. *verticilliflorum* (L.) Moench	*Sorghum bicolor* (L.) Moench	Sorghum;Grain sorghum	Gene Pool	1B
75	Poaceae	*Sorghum drummondii* (Nees ex Steud.) Millsp. & Chase	*Sorghum bicolor* (L.) Moench	Sorghum;Grain sorghum	Gene Pool	2
76	Poaceae	*Sorghum purpureosericeum* (Hochst. ex A.Rich.) Schweinf. & Asch	*Sorghum bicolor* (L.) Moench	Sorghum;Grain sorghum	Gene Pool	3
77	Poaceae	*Sorghum virgatum* (Hack.) Stapf	*Sorghum bicolor* (L.) Moench	Sorghum;Grain sorghum	Taxon Group	4
78	Poaceae	*Triticum turgidum* L.	*Triticum aestivum* L.	Common wheat	Gene Pool	1B
79	Poaceae	*Triticum turgidum* subsp. *durum* (Desf.) Husn.	*Triticum aestivum* L.	Common wheat	Gene Pool	1B
80	Papilionaceae	Vigna ambacensis Welw. ex Bak.	*Vigna unguiculata* (Linn.) Walp.	Cowpea	Taxon Group	4
81	Papilionaceae	Vigna desmodiodes Wilczek	*Vigna unguiculata* (Linn.) Walp.	Cowpea	Taxon Group	4

82	Papilionaceae	Vigna filicaulis Hepper	*Vigna unguiculata* (Linn.) Walp.	Cowpea	Taxon Group	4
83	Papilionaceae	Vigna gracilis (Guill. & Perr.) Hook. f.	*Vigna unguiculata* (Linn.) Walp.	Cowpea	Taxon Group	4
84	Papilionaceae	Vigna luteola (Jacq.) Benth.	*Vigna unguiculata* (Linn.) Walp.	Cowpea	Taxon Group	4
85	Papilionaceae	Vigna macrorrhyncha (Harms) Milne - Redhead	*Vigna unguiculata* (Linn.) Walp.	Cowpea	Taxon Group	4
86	Papilionaceae	Vigna marina (Burm.) Merill	*Vigna unguiculata* (Linn.) Walp.	Cowpea	Taxon Group	4
87	Papilionaceae	Vigna multinervis Hutch. & Dalz.	*Vigna unguiculata* (Linn.) Walp.	Cowpea	Taxon Group	4
88	Papilionaceae	Vigna nigritia Hook. f.	*Vigna unguiculata* (Linn.) Walp.	Cowpea	Taxon Group	4
89	Papilionaceae	Vigna oblongifolia A. Rich.	*Vigna unguiculata* (Linn.) Walp.	Cowpea	Taxon Group	4
90	Papilionaceae	Vigna racemosa (G. Don) Hutch. & Dalz.	*Vigna unguiculata* (Linn.) Walp.	Cowpea	Taxon Group	4
91	Papilionaceae	Vigna reticulata Hook. f.	*Vigna unguiculata* (Linn.) Walp.	Cowpea	Taxon Group	4
92	Papilionaceae	Vigna unguiculata subsp. aduensis (L.) Pasquet	*Vigna unguiculata* (Linn.) Walp.	Cowpea	Gene Pool	2
93	Papilionaceae	Vigna unguiculata subsp. alba (G.Don) Pasquet	*Vigna unguiculata* (Linn.) Walp.	Cowpea	Gene Pool	2
94	Papilionaceae	Vigna unguiculata subsp. baoulensis (A.Chev.) Pasquet	*Vigna unguiculata* (Linn.) Walp.	Cowpea	Gene Pool	2
95	Papilionaceae	Vigna unguiculata subsp. burundiensis Pasquet	*Vigna unguiculata* (Linn.) Walp.	Cowpea	Gene Pool	2
96	Papilionaceae	Vigna unguiculata subsp. dekindtiana (Harms) Verdc.	*Vigna unguiculata* (Linn.) Walp.	Cowpea	Gene Pool	1B
97	Papilionaceae	Vigna unguiculata subsp. letouzeyi Pasquet	*Vigna unguiculata* (Linn.) Walp.	Cowpea	Gene Pool	2
98	Papilionaceae	Vigna unguiculata subsp. pawekiae Pasquet	*Vigna unguiculata* (Linn.) Walp.	Cowpea	Gene Pool	2
99	Papilionaceae	Vigna unguiculata subsp. pubescens (R.Wilczek) Pasquet	*Vigna unguiculata* (Linn.) Walp.	Cowpea	Gene Pool	2

100	Papilionaceae	Vigna unguiculata subsp. stenophylla (Harv.) Marechal & al.	*Vigna unguiculata* (Linn.) Walp.	Cowpea	Gene Pool	1B
101	Papilionaceae	Vigna unguiculata subsp. tenuis (E.Mey) Marechal & al.	*Vigna unguiculata* (Linn.) Walp.	Cowpea	Gene Pool	1B
102	Papilionaceae	Vigna unguiculata subsp. unguiculata var. spontanea (Schweinf.) Pasquet	*Vigna unguiculata* (Linn.) Walp.	Cowpea	Gene Pool	1B

Fig. 3S1: Number of occurrence data and ex - situ collection in West African countries



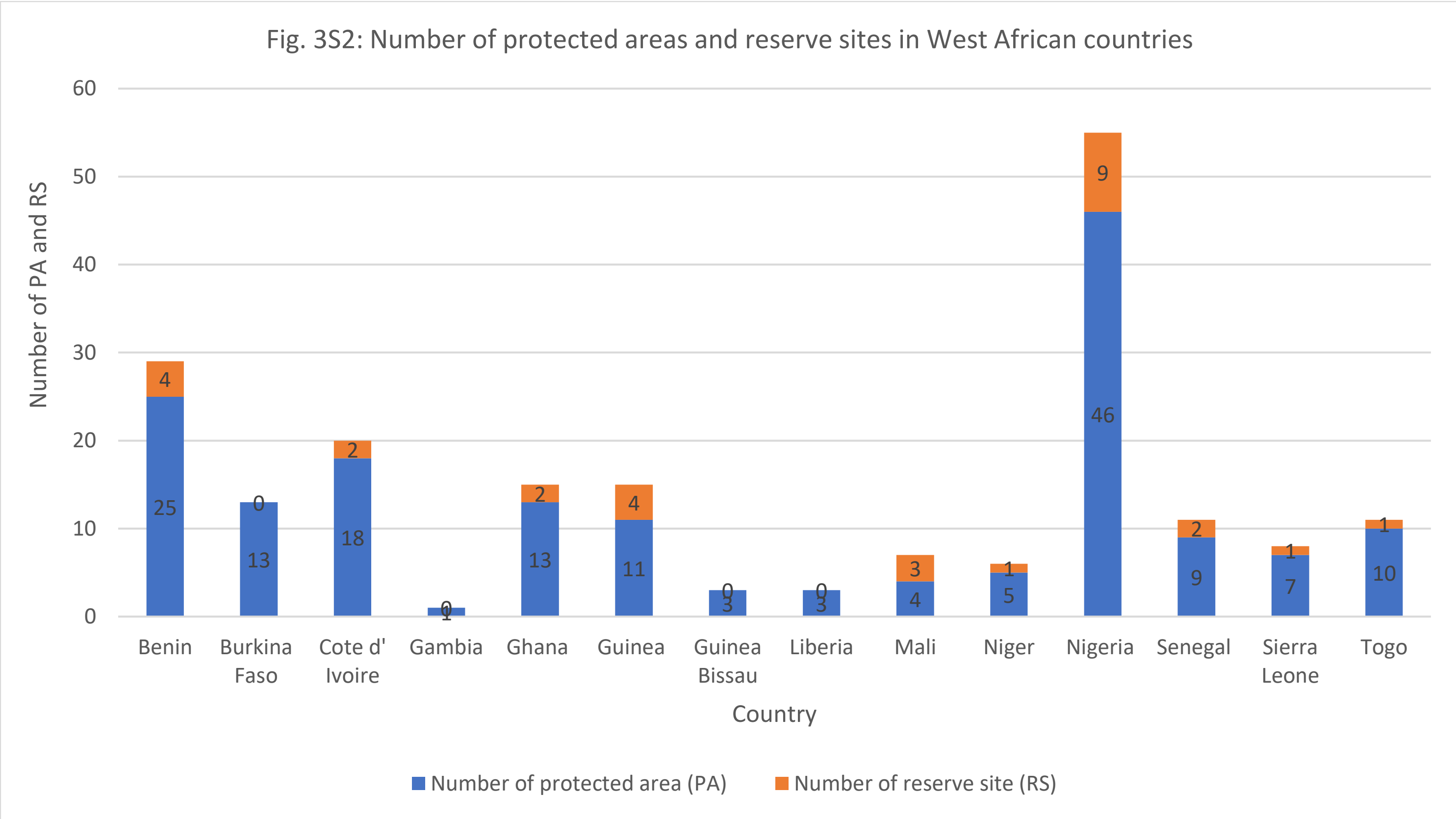


Fig. 3S2: Number of protected areas and reserve sites in West African countries
Number of PA and RS
60
50
40
30
20
10
0
4
25
0
13
2
18
0
1
2
13
4
11
0
3
0
3
3
4
1
5
9
46
2
9
1
7
1
10
Benin
Burkina Faso
Cote d' Ivoire
Gambia
Ghana
Guinea
Guinea Bissau
Liberia
Mali
Niger
Nigeria
Senegal
Sierra Leone
Togo
Country
Number of protected area (PA)
Number of reserve site (RS)

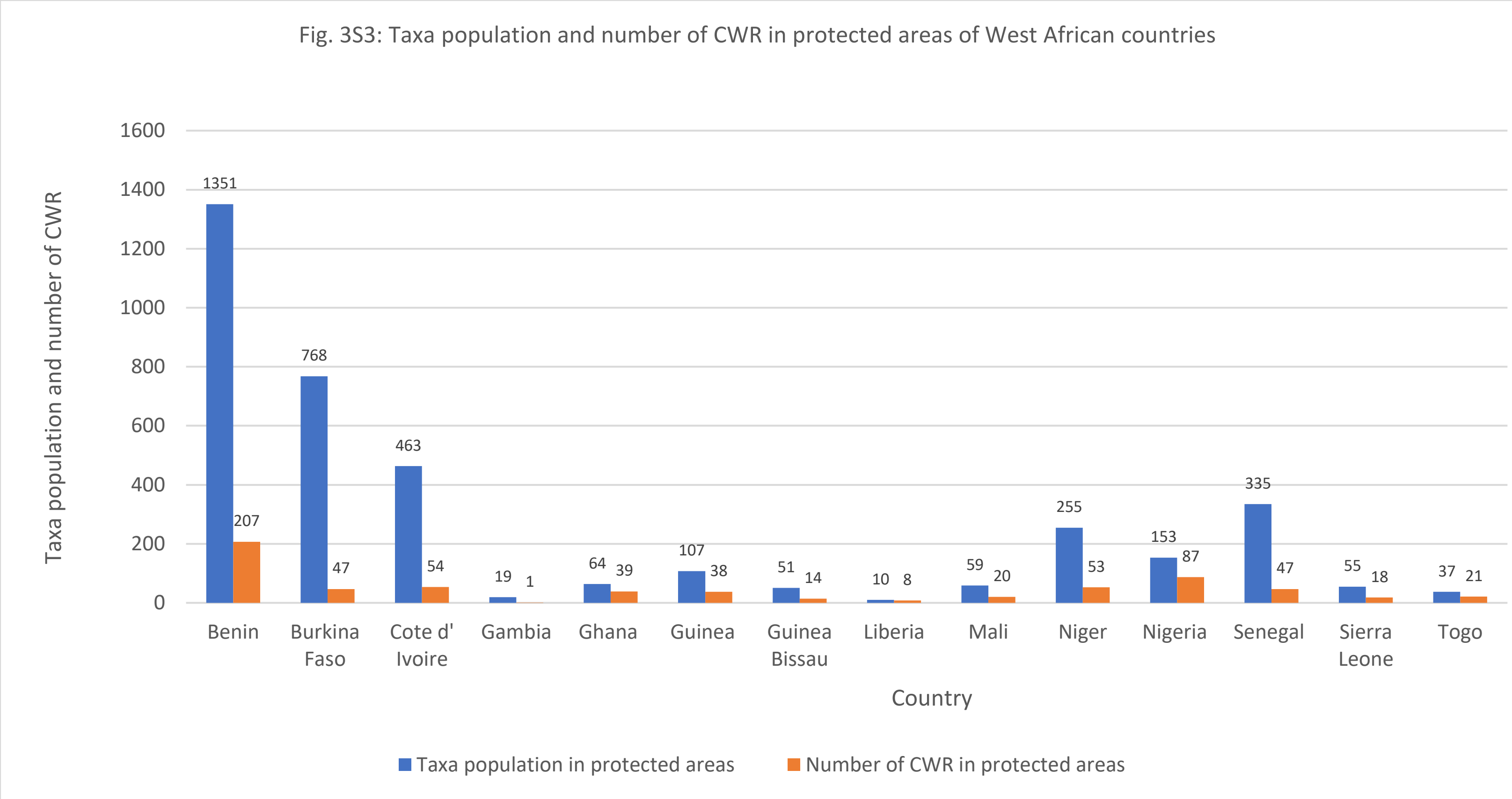


Fig. 3S3: Taxa population and number of CWR in protected areas of West African countries
Taxa population and number of CWR
1600
1400
1200
1000
800
600
400
200
0
1351
207
768
47
463
54
19
1
64
39
107
38
51
14
10
8
59
20
255
53
153
87
335
47
55
18
37
21
Benin
Burkina Faso
Cote d' Ivoire
Gambia
Ghana
Guinea
Guinea Bissau
Liberia
Mali
Niger
Nigeria
Senegal
Sierra Leone
Togo
Country
Taxa population in protected areas
Number of CWR in protected areas

Table 4S1: Taxa used for species distribution modeling and criteria for predicted distribution of global yam priority CWR

	Taxon	Number of occurrence records	ATAUC	STAUC	Threshold	Number of pixel with STAUC > 0	Number of pixel with STAUC < 0	Valid	Remark
1	*Dioscorera abyssinica* Hochst. ex Kunth	201	0.9767	0.0053	0.1378	59769	2100904	yes	SDM
2	*Dioscorera antaly* Jum. & H.Perrier	195	0.994	0.0019	0.2429	8070	2152603	yes	SDM
3	*Dioscorera arachidna* Prain & Burkill	71	0.9908	0.0062	0.3117	8887	2151786	yes	SDM
4	*Dioscorera baya* De Wild	156	0.9801	0.0083	0.1458	72978	2087695	yes	SDM
5	*Dioscorera brevipetiolata* Prain & Burkill	69	0.9921	0.0033	0.2245	17566	2143107	yes	SDM
6	*Dioscorera burkilliana* J. Miege	144	0.9889	0.0041	0.2199	32336	2128337	yes	SDM
7	*Dioscorera calcicola* Prain & Burkill	2	NA	NA	NA	NA	NA	NA	NA
8	*Dioscorera cirrhosa* Lour	194	0.9875	0.0051	0.0545	88123	2072550	yes	SDM
9	*Dioscorera decipiens* Hook.f.	97	0.9915	0.0017	0.2829	23655	2137018	yes	SDM
10	*Dioscorera glabra* Roxb.	384	0.9684	0.0095	0.1827	101498	2059175	yes	SDM
11	*Dioscorera hamiltonii* Hook.f.	265	0.9803	0.0068	0.1138	74152	2086521	yes	SDM
12	*Dioscorera hispida* Dennst.	343	0.9612	0.0106	0.1712	146527	2014146	yes	SDM
13	*Dioscorera inopinata* Prain & Burkill	6	0.999	-1	0.4734	716	2159957	yes	CA50
14	*Dioscorera lanata* Bail	8	0.966	-1	0.6848	916	2162091	yes	CA50
15	*Dioscorera mangenotiana* J. Miege	74	0.9934	0.0034	0.2366	9197	2151476	yes	SDM
16	*Dioscorera minutiflora* Engl	515	0.9764	0.0055	0.119	105368	2055305	yes	SDM
17	*Dioscorera nummularia* Lam	263	0.9787	0.0065	0.1832	59476	2101197	yes	SDM
18	*Dioscorera oryzetorum* Prain & Burkill	52	0.9933	0.0022	0.0164	24265	2138742	yes	SDM
19	*Dioscorera pentaphylla* L.	651	0.9546	0.0081	0.155	179987	1980686	yes	SDM
20	*Dioscorera praehensilis* Benth.	1229	0.9569	0.0052	0.1599	153735	2006938	yes	SDM
21	*Dioscorera pynaertii* De Wild.	7	0.9608	-1	0.3636	46197	2114476	yes	CA50
22	*Dioscorera sagittifolia* Pax	546	0.985	0.0051	0.1332	57113	2103560	yes	SDM

23	*Dioscorera schimperiana* Hochst. ex Kunth	344	0.9717	0.0087	0.1308	112504	2048169	yes	SDM
24	*Dioscorera smilacifolia* De Wild. & T. Durand	402	0.9834	0.0044	0.1814	56531	2104142	yes	SDM
25	*Dioscorera togoensis* R. Knuth	444	0.9877	0.0025	0.157	32532	2128141	yes	SDM
26	*Dioscorera transversa* R. Br.	2896	0.963	0.003	0.2212	40537	2120136	yes	SDM
27	*Dioscorera wallichii* Hook.f.	64	0.9793	0.0087	0.1039	110183	2050490	yes	SDM

Table 4S2: Population of global priority CWR in genebanks, in proteced areas and for further ex situ collection

	Taxon	**Number of Records**	**Number of accessions in genebank**	**Number of taxa population in PA**	**Number of PA found**	**Percentage population in genebank**	**Percentage population in PA**	**Taxa for further ex situ collection**
1	*Dioscorea abyssinica* Hochst. ex Kunth	200	10	10	4	5	5	Yes
2	*Dioscorea antaly* Jum. & H.Perrier	187	3	0	0	1.6		Yes
3	*Dioscorea arachidna* Prain & Burkill	67	11	4	2	16.41	5.97	Yes
4	*Dioscorea baya* De Wild	156	12	23	2	7.69	14.74	Yes
5	*Dioscorea brevipetiolata* Prain & Burkill	65	23	2	1	35.83	3.07	Yes
6	*Dioscorea burkilliana* J. Miege	144	31	5	3	21.52	3.47	Yes
7	*Dioscorea calcicola* Prain & Burkill	2		0	0			Yes
8	*Dioscorea cirrhosa* Lour	180	28	3	1	15.55	1.66	Yes

9	*Dioscorea decipiens* Hook.f.	97	11	3	2	11.34	3.09	Yes
10	*Dioscorea glabra* Roxb.	357	54	6	4	15.1	1.68	No
11	*Dioscorea hamiltonii* Hook.f.	256	32	2	1	12.07	0.75	Yes
12	*Dioscorea hispida* Dennst.	204	58	1	1	19.87	0.31	No
13	*Dioscorea inopinata* Prain & Burkill	4		0	0			Yes
14	*Dioscorea lanata* Bail	7		6	1		75	Yes
15	*Dioscorea mangenotiana* J. Miege	74	34	1	1	45.9	1.35	Yes
16	*Dioscorea minutiflora* Engl	445	70	30	5	15.7	6.74	No
17	*Dioscorea nummularia* Lam	192	9	0	0	4.68		Yes
18	*Dioscorea oryzetorum* Prain & Burkill	45	12	1	1	26.66	2.22	Yes
19	*Dioscorea pentaphylla* L.	414	60	15	3	14.49	3.62	No
20	*Dioscorea praehensilis* Benth.	1165	112	16	5	9.61	1.37	No
21	*Dioscorea pynaertii* De Wild.	7		0	0			Yes
22	*Dioscorea sagittifolia* Pax	546	7	0	0	1.28		Yes
23	*Dioscorea schimperiana* Hochst. ex Kunth	342	16	6	2	4.67	1.75	Yes
24	*Dioscorea smilacifolia* De Wild. & T. Durand	396	24	42	6	6.06	10.6	Yes
25	*Dioscorea togoensis* R. Knuth	443	6	4	2	1.35	0.9	Yes
26	*Dioscorea transversa* R. Br.	2759		247	37		8.95	Yes
27	*Dioscorea wallichii* Hook.f.	58	4	2	1	6.89	3.44	Yes
	Total	8812	627	429	85			

Table 4S3: Number of occurrence data, in proteced area and genebank by country

	Country	Number of occurrence records	Number of population in PA	Number of accession in genebank	Number of PA
1	Angola	24		1	
2	Australia	2777	247		37
3	Bangladesh	13		1	
4	Benin	1249		8	
5	Burkina Faso	32		1	
6	Burundi	25		3	
7	Cambodia	41		23	
8	Cameroon	392	36	16	2
9	Central African Republic (the)	67	34	1	1
10	Chad	2			1
11	China	322	13	22	1
12	Congo (the Democratic Republic of the)	193	56		2
13	Congo (the)	34	38	31	2
14	Cote d'Ivoire	511	12	210	1
15	Equatorial Guinea	18		2	
16	Eritrea	1			
17	Ethiopia	101	5	6	1
18	Fiji	13			
19	Gabon	116	6	11	2
20	Ghana	226		7	
21	Guinea	66	15	1	3
22	Guinea-Bissau	31		1	
23	India	222	1	24	1
24	Indonesia	75	3	14	1

25	Japan	12			
26	Kenya	26		1	
27	Lao People's Democratic Republic (the)	27		17	
28	Liberia	91		10	
29	Madagascar	180		5	
30	Malawi	51		1	
31	Malaysia	113		8	
32	Mali	12		4	
33	Mozambique	30	1	2	1
34	Myanmar	42		1	
35	Nepal	11			
36	New Caledonia	4			
37	Niger (the)	1			
38	Nigeria	147		2	
39	Papua New Guinea	78		5	
40	Philippines	117		28	
41	Rwanda	3			
42	Senegal	49			
43	Sierra Leone	57	1		1
44	Singapore	7			
45	South Sudan	2			
46	Sri Lanka	34		3	
47	Sudan (the)	5			
48	Taiwan (Province of China)	109		2	
49	Tanzania	103			
50	Thailand	564	17	62	3
51	Togo	131			
52	Uganda	52			
53	Vietnam	137	6	92	2
54	Yemen	7	6		1
55	Zambia	46			

56 Zimbabwe 13

8812 497 626

Table 4S4: Percentage conribution of selected environmenal variables used in MaxEnt

Ecogeographic variables	Taxon	D abyssinica	D antaly	D arachidna	D baya	brevipetiolata	D burkilliana	D calcicola	D cirrhosa	D decipiens	D glabra	D hamiltonii	D hispida	inopinata	D lanata	D mangenotiana	D minutiflora	D nummularia L	D oryzetorum	D pentaphylla	D praehensilis	D pynaertii	D sagittifolia	D schimperiana	D smilacifolia	D togoensis	D transversa	D wallichii
Bioclimatic variable																												
bio_1		1		1.2	0.8	0.4				1.8	4.3	0.1	1.1	4		0.1	0.1	0.6	1.5	2.1	0.3		8.9		0.7	8.2	0.3	8.6
bio_2		2		0.1	0.4	1.5			19	2.3	1.1	4.2	2.4		19.4			2		3.4	1.2		1.4	0.6	0.4	0.2	0.1	0.7
bio_3		2	22	5.7	0.1	1.4	9		1.7	8.6	0.6	6.4	1.2	2		7.3	7.3	10	4.4	2.9	0.4							
bio_4		1	3	1.6	34.8	0.2	26		4.7	1.9	1.2	0.4	1.2		2.3	4.6	4.6	34.8	0.5	2.8	37	4.2	21	32.2	15	0.8	14.7	1.1
bio_5		2				0.9	0					0.1	0.1					0.6		0.1	1.5							
bio_6		1		0.2		3.7			0.2		0.1	1.2	4.3		4.4	11	11	0.9			2.6	47	2.7	0.2	30	24.9	14.6	
bio_7					0.2	0.2			1.4		0.2	0.3	0.1		21.7			0.8	0.6	1.5	0.2	11		0.6	0.6	0.1		
bio_8		0			0.4		0				0.7	0.2				0.2	0.2			1.1								
bio_9		2	0								0.7		0.7	0		0.1	0.1	1.2		0.1	0.1							
bio_10		0								0.2		0.8						0.5			0.2							
bio_11		24		9.7	3.4	8.2	5		0.1		2.3	0.1	3.5	33		1.1	1.1	4.7	20		1.7							
bio_12		0		6.4	23	2.9	11			2.7	1.1		1	3				14.9		0.4	0.7	2	18	15.3	16	5.5	7.1	40
bio_13			14	28.8	0.2	31.8	0		9.9	26	53	0.5	52	0	3.3	4.8	4.8	0.7	26	56.9								
bio_14		7	1	4.4	1.1	7.3	6			0.3	1.7	0.1	2.9	1		1	1	2	5.2	0.4	3.6		9.1	0.6	2.2	8.1	0.3	13
bio_15		0	21	6.9	0.4	4.1	0		0.2	15	1.5	7.1	0.3		1.9	2.9	2.9		2.3		0.1							
bio_16		12		3.7	0.3	0.4	0		20	0.2	0.1	4.2	0.1	2	21.6			0.6			18							
bio_17		1		2.6		2.7	2		0.4	2.8	0.4	0.2	2.1			1.2	1.2	2.2	5.3	0.6	0.7		0.5	0.9	1.5	0.2	0.1	0.1

bio_18			23	0.6	5.9	4.6	3		25	4.4		12	3.2			4.9	4.9	1.7	2.9	0.4	0.3	0.4	1.1	0.2	1	0.1	41.2	0.6
bio_19		18		3.7	0.7	1.7	6		0.1	5.2	2.1	0.4	1.2			20	20	0.6	3.3	0.1	0.5		3.2	0.5	0.9	13.6	0.3	0.1
Edaphic variables																												
awc1		1																0.3			0.4			0.5		0.1	0.8	
awc2		1							0.4			0.9								0.1	0.1	0.2	0.2	0.4	0.1		0.6	
awc3		1			0.3		0		1.1				0.5					0.1				4	1.1	0.3		0.5	0.2	0.1
awct				0.1	5.3	1	1		0.4		0.5	0.1				7.1	7.1	0.2	0.4	0.2	0.1			1.6	0.2		0.3	0.1
r_horizon		5	9	5.9	5.4	2.1	6		0.3	2.4	0.7	0.4	0.5			8.8	8.8	5.5	1.1	0.9	3.2	8	2.8	4.8	8.3	11.6	2.6	0.7
t_bulk_den									0.1		0.4	0.1	0.1	0				0.1	1.3	1	0.2		0.1			0.2	0.1	
t_cec_sol			0		0.2		3		0.2	0.1	1.4	0.7	0.6		0.5			0.1	0.1	4.1	1.8	0.7	5.9	0.1	0.1	0.7	0.7	7.7
t_clay_cont		0	1	0.2	0.1	0.2			5.3	0.2	0.2	0.2	1.9		1.9	2.3	2.3	0.2		2.3	0.2		0.8	0.7	0.2	0.6	0.4	3.9
t_coarse_frag		16	5	8.5	9.1	10.4	17		2.2	21	9.5	8.1	5.7	0	3.2	22	22	11.4	6.8	7.8	10	2.6	18	3.1	14	21.2	1.4	21
t_oc_cont		1		0.1	0.1		0				0.3	0.5	0.1	3	11.5			0.1		0.1	0.9							
t_oc_den				0.4	0.2	0.1			0.3		0.1	0.1						0.3	0.2		0.1				0.1			0.2
t_oc_stock		0		0.4	0.2						0.1							0.1		0.1	0.2							
t_ph_hox		1		0.8	0.7	0.4	1		1	0.2	0.1	1.5	1.8	3	4.3			0.1	2.1	0.6	7.4		0.8	1.8	1.6	0.8	0.7	0.2
t_ph_kcl		0	1	0.6	0.1	0.2	0		2		1.8		1.5	1				0.9	3.8	2.8	2	21	0.3	1.3	0.1	1.4	0.2	
t_silt			1	5.6	5	4.3	3		1.1	2.5	7	4.9	7.7	7		0.8	0.8	2.2	4.4	5.5	1.2		1	1.7	5.7	0.3	13.4	0.4
Ecogeographic variables																												
aspect			1	0.3	0.9	1.1	0		0.2	0.8	0.2	0.2	0.3	28				0.4		0.4	0.2		0.1	0.4		0.1		0.1
elev		1		0.9	0.2	6	0		0.3	0.1	0.2	0.2	0.2	14				0.1	6	0.2	0.4		2.2	30.5	0.2	0.4	3.3	0.7
eastness		2	1	0.1	0.1	0.4			0.2		0.3	1.1	0.3		4			2.3	0.4		1.6		1.3	1.3	1.3	0.4	1.2	0.6
northness		0				1.2			1.1		0.1		0.3					0.7	0.9	0.7								
slope		0	0	0.5	0.1	0.5			1.8	0.4	1	0.8																
Total number of variables		30	16	28	30	29	24		29	22	33	32	31	16	13	18	18	35	23	29	34	11	22	23	22	23	23	20

Table 4S5: Ecogeographic variables used for the SDM and ELC map analysis

No	Component	Variable	Description	Unit	Source
1	Bioclim	bio_1	Annual average temperature	° C	WorldClim
2	Bioclim	bio_2	Average daytime temperature range	° C	WorldClim
3	Bioclim	bio_3	Isothermality	° C	WorldClim
4	Bioclim	bio_4	Temperature seasonality	° C	WorldClim
5	Bioclim	bio_5	Maximum temperature for the warmest month	° C	WorldClim
6	Bioclim	bio_6	Maximum temperature for the coldest month	° C	WorldClim
7	Bioclim	bio_7	Annual temperature range	° C	WorldClim
8	Bioclim	bio_8	Average temperature for the quarter with the most precipitation	° C	WorldClim
9	Bioclim	bio_9	Average temperature for the driest quarter	° C	WorldClim
10	Bioclim	bio_10	Average temperature for the hotest quarter	° C	WorldClim
11	Bioclim	bio_11	Average temperature for the coldest quarter	° C	WorldClim
12	Bioclim	bio_12	Annual precipitation	mm	WorldClim
13	Bioclim	bio_13	Precipitation during the wettest month	mm	WorldClim
14	Bioclim	bio_14	Precipitation during the driest month	mm	WorldClim
15	Bioclim	bio_15	Seasonality of precipitation (variation coefficient)	mm	WorldClim
16	Bioclim	bio_16	Precipitation during the wettest quarter (3 rainest months)	mm	WorldClim
17	Bioclim	bio_17	Precipitation during the driest quarter (3 driest months)	mm	WorldClim
18	Bioclim	bio_18	Precipitation during the hottest quarter (3 hottest months)	mm	WorldClim
19	Bioclim	bio_19	Precipitation during the coldest quarter (3 coldest months)	mm	WorldClim
20	Bioclim	vapr_annual	Water vapour pressure annual	kPa	WorldClim
21	Edaphic	t_sand	Sand content in top soil	%weight	ISRIC
22	Edaphic	t_silt	Silt content in top soil	%weight	ISRIC
23	Edaphic	t_clay_cont	Clay content in top soil	%weight	ISRIC
24	Edaphic	t_ref_bulk	Bulk density reference in top soil	kg/dm3	ISRIC
25	Edaphic	t_oc_cont	Organic carbon content in top soil	%weight	ISRIC
26	Edaphic	t_cec	Cation exchange capacity in top soil	cmol/kg	ISRIC
27	Edaphic	t_phh2o	top soil pH in a soil water solution	-log(H+)	ISRIC

28	Edaphic	t_phhox	Soil Ph x 10 in H2O	-log(H+)	ISRIC
29	Edaphic	t_awc1	Available soil water capacity (volumetric fraction) for h1 top soil	ml	ISRIC
30	Edaphic	t_awc2	Available soil water capacity (volumetric fraction) for h2 top soil	ml	ISRIC
31	Edaphic	t_awc3	Available soil water capacity (volumetric fraction) for h3 top soil	ml	ISRIC
32	Edaphic	t_awct	Available soil water capacity (volumetric fraction) for tS top soil	ml	ISRIC
33	Edaphic	t_coarse_frag	Coarse fragments volumetrics	%weight	ISRIC
34	Edaphic	t_oc_den	Soil organic carbon density	kg/m3	ISRIC
35	Edaphic	r_horizon	Probability of occurrence of R horizon		ISRIC
36	Edaphic	t_oc_stock	Soil organic carbon stock	tons/ha	ISRIC
37	Geophysical	aspect	Aspect of the land	degree (°)	NASA
38	Geophysical	elev	Elevation. Height above sea level	m	WorldClim
39	Geophysical	slope	Slope of the land surface	degree (°)	NASA
40	Geophysical	srad_1	Solar radiation January	W/m2	WorldClim
41	Geophysical	srad_2	Solar radiation February	W/m2	WorldClim
42	Geophysical	srad_3	Solar radiation March	W/m2	WorldClim
43	Geophysical	srad_4	Solar radiation April	W/m2	WorldClim
44	Geophysical	srad_5	Solar radiation May	W/m2	WorldClim
45	Geophysical	srad_6	Solar radiation June	W/m2	WorldClim
46	Geophysical	srad_7	Solar radiation July	W/m2	WorldClim
47	Geophysical	srad_8	Solar radiation August	W/m2	WorldClim
48	Geophysical	srad_9	Solar radiation September	W/m2	WorldClim
49	Geophysical	srad_10	Solar radiation October	W/m2	WorldClim
50	Geophysical	srad_11	Solar radiation November	W/m2	WorldClim
51	Geophysical	srad_12	Solar radiation December	W/m2	WorldClim
52	Geophysical	srad_annual	Solar radiation annual	W/m2	WorldClim
53	Geophysical	wind_annual	Wind speed annual	m/s	WorldClim

Table 4S6: Seleced ecogeographic variables used for the ELC map analysis

Ecogeographic variables / **Taxon**	D abyssinica	D antaly	D arachidna	D baya	D burkilliana	D cirrhosa	D hispida	D minutiflora	D praehensilis	D sagittifolia	D schimperiana	D transversa	D wallichii
Bioclimatic variable													
	bio_4	bio_1	bio_6	bio_4	bio_1	bio_1	bio_4	bio_4	bio_4	bio_6	bio_1	bio_1	bio_4
	bio_6	bio_6	bio_7	bio_14	bio_9	bio_11	bio_6	bio_9	bio_5	bio_9	bio_4	bio_9	bio_6
	bio_7	bio_9	bio_11	bio_17	bio_10	bio_17	bio_7	bio_10	bio_9	bio_16	bio_9	bio_11	bio_10
	vapr_annual	bio_11	vapr_annual	bio_19	bio_12	vapr_annual	vapr_annual	bio_19	bio_12	vapr_annual	bio_11	vapr_annual	bio_16
Edaphic variables													
	t_awc1	t_awct	t_awc1	t_awct	t_awc1	t_awct	t_awc1	t_awc1	t_awc1	t_awc1	t_awc1	t_awct	t_awc1
	t_clay_cont	t_bulk_den	t_awc2	t_bulk_den	t_clay_cont	r_horizon	t_awct	t_awct	t_clay_cont	t_bulk_den	t_awct	t_oc_cont	t_awc2
	t_ph_hox	t_oc_cont	t_bulk_den	t_oc_den	t_oc_stock	t_bulk_den	r_horizon	t_bulk_den	t_oc_den	t_sand_cont	t_oc_stock	t_oc_den	t_awc3
	t_sand_cont	t_oc_den	t_oc_den	t_oc_stock	t_sand_cont	t_oc_stock	t_oc_den	t_oc_stock	t_oc_stock	t_silt	t_bulk_den	t_oc_stock	t_oc_den
Ecogeographic variables													
	elev	elev	elev	elev	srad_annual	srad_annual	srad_annual	elev	elev	elev	srad_annual	srad_annual	elev
	srad_annual	srad_annual	slope	wind_annual	wind_annual	wind_annual	wind_annual	srad_annual	srad_annual	srad_annual	wind_annual	wind_annual	srad_annual
	wind_annual	wind_annual	wind_annual							wind_annual			wind_annual

Total number of variables	11	11	11	10	10	10	10	10	10	11	10	10	11

Table 4S7: Number of ELC categories, genebank and ELC map percentage frequencies of global yam priority CWR

S/N		ELC_CAT	GBfreq	GBpercentage	GB_quartile_classificaion	TotalCellsFreq	ELCmap_percentage	Quartile_class _ELCmap
1	D. abyssinica	1	2	0.33557047	baja/low	1589	1.893041375	media alta/mid-high
		2	0	0	nula	2000	2.382682662	media alta/mid-high
		3	183	30.70469799	alta/high	2227	2.653117145	media alta/mid-high
		4	0	0	nula	2398	2.856836512	media alta/mid-high
		5	2	0.33557047	baja/low	657	0.782711255	media baja/mid-low
		6	0	0	nula	84	0.100072672	baja/low
		7	32	5.369127517	alta/high	18568	22.12082584	alta/high
		8	0	0	nula	1117	1.330728267	media baja/mid-low
		9	229	38.42281879	alta/high	7107	8.466862841	alta/high
		10	21	3.523489933	media alta/mid-high	8563	10.20145582	alta/high
		11	3	0.503355705	media baja/mid-low	4946	5.892374224	alta/high
		12	79	13.25503356	alta/high	15042	17.9201563	alta/high
		13	0	0	nula	80	0.095307306	baja/low
		14	5	0.838926174	media alta/mid-high	425	0.506320066	media baja/mid-low
		15	0	0	nula	764	0.910184777	media baja/mid-low
		16	1	0.167785235	baja/low	1160	1.381955944	media alta/mid-high
		17	0	0	nula	44	0.052419019	baja/low
		18	0	0	nula	3962	4.720094354	alta/high
		19	3	0.503355705	media baja/mid-low	235	0.279965213	baja/low
		20	0	0	nula	169	0.201336685	baja/low
		21	2	0.33557047	baja/low	71	0.084585235	baja/low
		22	4	0.67114094	media baja/mid-low	2014	2.399361441	media alta/mid-high
		23	19	3.187919463	media alta/mid-high	5889	7.015809099	alta/high

		24	0	0	nula	1057	1.259247787	media baja/mid-low
		25	2	0.33557047	baja/low	653	0.777945889	media baja/mid-low
		26	0	0	nula	2	0.002382683	baja/low
		27	0	0	nula	1042	1.241377667	media baja/mid-low

2	D. antaly	ELC_CAT	GBfreq	GBpercentage	GB_quartile_classification	TotalCellsFreq	ELCmap_percentage	Quartile_classes_ELCmap
		1	13	7.692307692	media alta/mid-high	1391	17.98319328	alta/high
		2	1	0.591715976	baja/low	289	3.736263736	media alta/mid-high
		3	2	1.183431953	media baja/mid-low	174	2.249515191	media alta/mid-high
		4	1	0.591715976	baja/low	629	8.131868132	alta/high
		5	0	0	nula	312	4.033613445	media alta/mid-high
		6	2	1.183431953	media baja/mid-low	284	3.671622495	media alta/mid-high
		7	5	2.958579882	media alta/mid-high	217	2.805429864	media alta/mid-high
		8	0	0	nula	87	1.124757595	media baja/mid-low
		9	0	0	nula	23	0.297349709	media baja/mid-low
		10	0	0	nula	65	0.840336134	media baja/mid-low
		11	0	0	nula	30	0.387847447	media baja/mid-low
		12	0	0	nula	1	0.012928248	baja/low
		13	15	8.875739645	alta/high	776	10.03232062	alta/high
		14	4	2.366863905	media baja/mid-low	641	8.287007111	alta/high
		15	0	0	nula	106	1.370394312	media baja/mid-low
		16	0	0	nula	1	0.012928248	baja/low
		17	0	0	nula	1	0.012928248	baja/low
		18	1	0.591715976	baja/low	5	0.064641241	baja/low
		19	0	0	nula	15	0.193923723	baja/low
		20	1	0.591715976	baja/low	43	0.555914674	media baja/mid-low
		21	0	0	nula	116	1.499676794	media alta/mid-high
		22	0	0	nula	4	0.051712993	baja/low
		23	0	0	nula	1	0.012928248	baja/low
		24	0	0	nula	18	0.232708468	media baja/mid-low
		25	71	42.01183432	alta/high	784	10.13574661	alta/high

		26	10	5.917159763	media alta/mid-high	315	4.07239819	alta/high
		27	17	10.0591716	alta/high	167	2.159017453	media alta/mid-high

3	D. arachidna	ELC_CAT	GBfreq	GBpercentage	GB_quartile_classification	TotalCellsFreq	ELCmap_percentage	Quartile_classes_ELCmap
		1	0	0	nula	2	0.010076582	baja/low
		2	0	0	nula	5	0.025191455	baja/low
		3	0	0	nula	8	0.040306328	baja/low
		4	0	0	nula	103	0.518943974	media baja/mid-low
		5	0	0	nula	54	0.272067715	media baja/mid-low
		6	0	0	nula	542	2.730753728	media alta/mid-high
		7	1	3.03030303	baja/low	3278	16.51551794	alta/high
		8	0	0	nula	580	2.922208787	media alta/mid-high
		9	3	9.090909091	media baja/mid-low	2608	13.13986296	alta/high
		10	4	12.12121212	media baja/mid-low	1166	5.87464732	alta/high
		11	0	0	nula	338	1.702942362	media baja/mid-low
		12	4	12.12121212	media baja/mid-low	1059	5.335550181	media alta/mid-high
		13	1	3.03030303	baja/low	946	4.766223297	media alta/mid-high
		14	0	0	nula	9	0.045344619	baja/low
		15	0	0	nula	478	2.408303104	media baja/mid-low
		16	11	33.33333333	alta/high	2533	12.76199113	alta/high
		17	0	0	nula	633	3.18923821	media alta/mid-high
		18	5	15.15151515	alta/high	3920	19.75010077	alta/high
		19	0	0	nula	22	0.110842402	baja/low
		20	0	0	nula	24	0.120918984	baja/low
		21	0	0	nula	75	0.377871826	media baja/mid-low

4	D. baya	ELC_CAT	GBfreq	GBpercentage	GB_quartile_classification	TotalCellsFreq	ELCmap_percentage	Quartile_classes_ELCmap
		1	0	0	nula	67	0.136534072	baja/low
		2	3	3.225806452	media baja/mid-low	490	0.998532768	media baja/mid-low

3	0	0	nula	275	0.560401043	media baja/mid-low
4	4	4.301075269	media baja/mid-low	760	1.548744702	media baja/mid-low
5	0	0	nula	92	0.187479622	baja/low
6	4	4.301075269	media baja/mid-low	2239	4.562683404	media alta/mid-high
7	0	0	nula	48	0.097815455	baja/low
8	11	11.82795699	alta/high	9165	18.67663841	alta/high
9	5	5.376344086	media alta/mid-high	4162	8.481415064	alta/high
10	1	1.075268817	baja/low	191	0.389223997	baja/low
11	1	1.075268817	baja/low	3052	6.21943267	alta/high
12	0	0	nula	820	1.67101402	media baja/mid-low
13	0	0	nula	246	0.501304206	baja/low
14	1	1.075268817	baja/low	3686	7.511411803	alta/high
15	0	0	nula	915	1.864607108	media alta/mid-high
16	7	7.52688172	alta/high	290	0.590968373	media baja/mid-low
17	4	4.301075269	media baja/mid-low	4083	8.320427127	alta/high
18	7	7.52688172	alta/high	3145	6.408950114	alta/high
19	1	1.075268817	baja/low	537	1.094310401	media baja/mid-low
20	38	40.86021505	alta/high	7047	14.36053146	alta/high
21	4	4.301075269	media baja/mid-low	1920	3.912618194	media alta/mid-high
22	0	0	nula	189	0.385148353	baja/low
23	0	0	nula	274	0.558363221	media baja/mid-low
24	0	0	nula	969	1.974649495	media alta/mid-high
25	0	0	nula	42	0.085588523	baja/low
26	0	0	nula	1361	2.773475709	media alta/mid-high
27	0	0	nula	1289	2.626752527	media alta/mid-high

5	D. burkilliana	ELC_CAT	GBfreq	GBpercentage	GB_quartile_classification	TotalCellsFreq	ELCmap_percentage	Quartile_classes_ELCmap
		1	0	0	nula	1	0.002716284	baja/low
		2	0	0	nula	114	0.30965639	media baja/mid-low
		3	0	0	nula	19	0.051609398	media baja/mid-low

		4	0	0	nula	127	0.344968084	media baja/mid-low
		5	3	2.23880597	media baja/mid-low	1880	5.106614152	alta/high
		6	0	0	nula	441	1.197881298	media alta/mid-high
		7	0	0	nula	1	0.002716284	baja/low
		8	0	0	nula	42	0.114083933	media baja/mid-low
		9	0	0	nula	5	0.013581421	baja/low
		10	0	0	nula	2	0.005432568	baja/low
		11	0	0	nula	5	0.013581421	baja/low
		12	0	0	nula	7	0.019013989	baja/low
		13	0	0	nula	17	0.04617683	media baja/mid-low
		14	75	55.97014925	alta/high	9513	25.84001087	alta/high
		15	3	2.23880597	media baja/mid-low	654	1.776449817	media alta/mid-high
		16	0	0	nula	89	0.241749287	media baja/mid-low
		17	4	2.985074627	media alta/mid-high	5627	15.28453076	alta/high
		18	24	17.91044776	alta/high	8061	21.89596632	alta/high
		19	0	0	nula	1495	4.060844764	media alta/mid-high
		20	0	0	nula	549	1.491239984	media alta/mid-high
		21	2	1.492537313	baja/low	1680	4.563357327	media alta/mid-high
		22	2	1.492537313	baja/low	206	0.559554529	media alta/mid-high
		23	13	9.701492537	media alta/mid-high	2779	7.548553579	alta/high
		24	5	3.731343284	media alta/mid-high	2013	5.46787994	alta/high
		25	0	0	nula	124	0.336819231	media baja/mid-low
6	D. cirrhosa	ELC_CAT	GBfreq	GBpercentage	GB_quartile_classification	TotalCellsFreq	ELCmap_percentage	Quartile_classes_ELCmap
		1	0	0	nula	2	0.005201425	baja/low
		2	0	0	nula	1108	2.881589556	media alta/mid-high
		3	0	0	nula	558	1.451197628	media baja/mid-low
		4	2	1.652892562	baja/low	304	0.790616629	media baja/mid-low
		5	1	0.826446281	baja/low	1669	4.340589321	media alta/mid-high
		6	0	0	nula	2	0.005201425	baja/low

		7	9	7.438016529	media alta/mid-high	9748	25.35174638	alta/high
		8	10	8.26446281	alta/high	3633	9.448388859	alta/high
		9	2	1.652892562	baja/low	1030	2.678733973	media alta/mid-high
		10	0	0	nula	239	0.62157031	media baja/mid-low
		11	0	0	nula	461	1.198928506	media baja/mid-low
		12	14	11.57024793	alta/high	34	0.088424228	baja/low
		13	2	1.652892562	baja/low	103	0.267873397	baja/low
		14	8	6.611570248	media alta/mid-high	7859	20.43900029	alta/high
		15	6	4.958677686	media alta/mid-high	4105	10.6759252	alta/high
		16	0	0	nula	2	0.005201425	baja/low
		17	3	2.479338843	media baja/mid-low	786	2.0441601	media alta/mid-high
		18	4	3.305785124	media baja/mid-low	758	1.971340147	media baja/mid-low

7	D. hispida	ELC_CAT	GBfreq	GBpercentage	GB_quartile_classification	TotalCellsFreq	ELCmap_percentage	Quartile_classes_ELCmap
		1	3	2.127659574	media baja/mid-low	10953	14.3691129	alta/high
		2	9	6.382978723	media alta/mid-high	6056	7.944795739	media alta/mid-high
		3	15	10.63829787	alta/high	9004	11.81224254	alta/high
		4	0	0	nula	3133	4.110146144	media alta/mid-high
		5	1	0.709219858	baja/low	1730	2.269566814	media baja/mid-low
		6	0	0	nula	2	0.002623777	baja/low
		7	5	3.546099291	media alta/mid-high	1533	2.011124813	media baja/mid-low
		8	10	7.092198582	media alta/mid-high	1047	1.373547084	media baja/mid-low
		9	0	0	nula	309	0.405373495	baja/low
		10	1	0.709219858	baja/low	1722	2.259071708	media baja/mid-low
		11	2	1.418439716	media baja/mid-low	2891	3.792669168	media alta/mid-high
		12	1	0.709219858	baja/low	342	0.44866581	media baja/mid-low
		13	2	1.418439716	media baja/mid-low	105	0.137748275	baja/low
		14	0	0	nula	93	0.122005615	baja/low
		15	46	32.62411348	alta/high	8030	10.53446331	alta/high
		16	18	12.76595745	alta/high	6972	9.146485451	alta/high

		17	1	0.709219858	baja/low	1040	1.364363865	media baja/mid-low
		18	0	0	nula	53	0.069530082	baja/low
		19	0	0	nula	2864	3.757248183	media alta/mid-high
		20	0	0	nula	45	0.059034975	baja/low
		21	0	0	nula	2661	3.490934852	media alta/mid-high
		22	2	1.418439716	media baja/mid-low	8002	10.49773043	alta/high

8	D. munitiflora	ELC_CAT	GBfreq	GBpercentage	GB_quartile_classification	TotalCellsFreq	ELCmap_percentage	Quartile_classes_ELCmap
		1	0	0	nula	18	0.028062736	baja/low
		2	0	0	nula	309	0.481743631	media baja/mid-low
		3	0	0	nula	325	0.506688285	media baja/mid-low
		4	2	0.735294118	baja/low	238	0.371051729	baja/low
		5	0	0	nula	118	0.183966824	baja/low
		6	0	0	nula	436	0.679741823	media baja/mid-low
		7	0	0	nula	393	0.612703065	media baja/mid-low
		8	21	7.720588235	media alta/mid-high	13635	21.25752237	alta/high
		9	10	3.676470588	media alta/mid-high	3102	4.836144804	alta/high
		10	8	2.941176471	media baja/mid-low	272	0.424059119	baja/low
		11	0	0	nula	538	0.838763992	media baja/mid-low
		12	7	2.573529412	media baja/mid-low	1103	1.719622088	media alta/mid-high
		13	2	0.735294118	baja/low	2483	3.8710985	media alta/mid-high
		14	1	0.367647059	baja/low	985	1.535655265	media alta/mid-high
		15	4	1.470588235	media baja/mid-low	2189	3.412740482	media alta/mid-high
		16	0	0	nula	54	0.084188207	baja/low
		17	0	0	nula	72	0.112250943	baja/low
		18	10	3.676470588	media alta/mid-high	1526	2.37909638	media alta/mid-high
		19	11	4.044117647	media alta/mid-high	8271	12.8948271	alta/high
		20	59	21.69117647	alta/high	15881	24.75912818	alta/high
		21	1	0.367647059	baja/low	454	0.707804559	media baja/mid-low
		22	0	0	nula	332	0.517601572	media baja/mid-low

		23	3	1.102941176	media baja/mid-low	2241	3.493810608	media alta/mid-high
		24	0	0	nula	251	0.39131926	baja/low
		25	82	30.14705882	alta/high	2568	4.003616975	alta/high
		26	26	9.558823529	alta/high	3699	5.766892208	alta/high
9	D. praehensilis	ELC_CAT	GBfreq	GBpercentage	GB_quartile_classification	TotalCellsFreq	ELCmap_percentage	Quartile_classes_ELCmap
		1	26	2.823018458	media alta/mid-high	4976	4.354713084	alta/high
		2	57	6.188925081	alta/high	1634	1.42998416	media baja/mid-low
		3	1	0.108577633	baja/low	342	0.29929901	baja/low
		4	243	26.38436482	alta/high	13355	11.68753883	alta/high
		5	185	20.08686211	alta/high	4922	4.307455346	media alta/mid-high
		6	9	0.977198697	media baja/mid-low	3449	3.018369258	media alta/mid-high
		7	16	1.737242128	media alta/mid-high	6889	6.028862226	alta/high
		8	4	0.434310532	media baja/mid-low	3241	2.836339451	media alta/mid-high
		9	17	1.845819761	media alta/mid-high	3208	2.807459722	media alta/mid-high
		10	13	1.411509229	media alta/mid-high	6425	5.622795733	alta/high
		11	72	7.817589577	alta/high	20339	17.79953967	alta/high
		12	0	0	nula	175	0.153150078	baja/low
		13	9	0.977198697	media baja/mid-low	408	0.357058468	media baja/mid-low
		14	150	16.28664495	alta/high	2652	2.320880044	media baja/mid-low
		15	6	0.651465798	media baja/mid-low	20	0.017502866	baja/low
		16	3	0.325732899	baja/low	1831	1.602387391	media baja/mid-low
		17	6	0.651465798	media baja/mid-low	3385	2.962360086	media alta/mid-high
		18	0	0	nula	66	0.057759458	baja/low
		19	1	0.108577633	baja/low	46	0.040256592	baja/low
		20	2	0.217155266	baja/low	71	0.062135175	baja/low
		21	3	0.325732899	baja/low	1493	1.306588954	media baja/mid-low
		22	3	0.325732899	baja/low	635	0.555715998	media baja/mid-low
		23	0	0	nula	44	0.038506305	baja/low
		24	14	1.520086862	media alta/mid-high	7646	6.691345708	alta/high

		25	34	3.691639522	media alta/mid-high	22436	19.63471518	alta/high
		26	2	0.217155266	baja/low	1472	1.288210945	media baja/mid-low
10	D. sagittifolia	ELC_CAT	GBfreq	GBpercentage	GB_quartile_classification	TotalCellsFreq	ELCmap_percentage	Quartile_classes_ELCmap
		1	0	0	nula	1407	2.581083064	media alta/mid-high
		2	0	0	nula	786	1.441884356	media baja/mid-low
		3	0	0	nula	4	0.007337834	baja/low
		4	0	0	nula	365	0.669577341	media baja/mid-low
		5	6	1.459854015	media baja/mid-low	4406	8.082624009	alta/high
		6	0	0	nula	5	0.009172292	baja/low
		7	1	0.243309002	baja/low	533	0.977766363	media baja/mid-low
		8	0	0	nula	1534	2.81405929	media alta/mid-high
		9	0	0	nula	2551	4.679703552	alta/high
		10	0	0	nula	1404	2.575579689	media alta/mid-high
		11	0	0	nula	350	0.642060464	media baja/mid-low
		12	0	0	nula	73	0.133915468	baja/low
		13	10	2.433090024	media alta/mid-high	284	0.520986205	baja/low
		14	3	0.729927007	media baja/mid-low	541	0.992442031	media baja/mid-low
		15	0	0	nula	8	0.014675668	baja/low
		16	22	5.352798054	alta/high	14433	26.47673907	alta/high
		17	2	0.486618005	baja/low	2469	4.529277957	alta/high
		18	304	73.96593674	alta/high	5111	9.375917229	alta/high
		19	3	0.729927007	media baja/mid-low	1461	2.680143822	media alta/mid-high
		20	1	0.243309002	baja/low	863	1.583137658	media baja/mid-low
		21	0	0	nula	18	0.033020252	baja/low
		22	10	2.433090024	media alta/mid-high	2125	3.898224244	media alta/mid-high
		23	8	1.946472019	media alta/mid-high	2115	3.87987966	media alta/mid-high
		24	33	8.02919708	alta/high	10520	19.29850308	alta/high

11	D. schimperiana	ELC_CAT	GBfreq	GBpercentage	GB_quartile_classification	TotalCellsFreq	ELCmap_percentage	Quartile_classes_ELCmap
		1	5	2.336448598	media baja/mid-low	16751	14.75209159	alta/high
		2	13	6.074766355	media alta/mid-high	18794	16.55129899	alta/high
		3	6	2.803738318	media baja/mid-low	2673	2.354029062	media alta/mid-high
		4	18	8.411214953	media alta/mid-high	14063	12.38485249	alta/high
		5	17	7.943925234	media alta/mid-high	16173	14.24306473	alta/high
		6	3	1.401869159	baja/low	2618	2.30559225	media alta/mid-high
		7	0	0	nula	773	0.680757376	media baja/mid-low
		8	1	0.46728972	baja/low	1670	1.470717745	media alta/mid-high
		9	0	0	nula	38	0.033465434	baja/low
		10	0	0	nula	1	0.000880669	baja/low
		11	0	0	nula	6	0.005284016	baja/low
		12	0	0	nula	27	0.023778071	baja/low
		13	0	0	nula	38	0.033465434	baja/low
		14	0	0	nula	98	0.086305592	media baja/mid-low
		15	0	0	nula	188	0.16556583	media baja/mid-low
		16	0	0	nula	188	0.16556583	media baja/mid-low
		17	5	2.336448598	media baja/mid-low	437	0.384852488	media baja/mid-low
		18	53	24.76635514	alta/high	22416	19.74108322	alta/high
		19	31	14.48598131	alta/high	7689	6.771466314	media alta/mid-high
		20	58	27.10280374	alta/high	5744	5.058564509	media alta/mid-high

12	D. transversa	ELC_CAT	GBfreq	GBpercentage	GB_quartile_classification	TotalCellsFreq	ELCmap_percentage	Quartile_classes_ELCmap
		1	2	0.089645899	baja/low	7	0.021301199	baja/low
		2	7	0.313760645	media baja/mid-low	2279	6.935061773	alta/high
		3	0	0	nula	7	0.021301199	baja/low
		4	33	1.479157329	media alta/mid-high	101	0.307345871	media baja/mid-low
		5	33	1.479157329	media alta/mid-high	91	0.276915586	media baja/mid-low
		6	0	0	nula	197	0.599476599	media baja/mid-low

7	24	1.075750784	media baja/mid-low	560	1.704095916	media alta/mid-high
8	53	2.375616316	media alta/mid-high	3788	11.52699166	alta/high
9	0	0	nula	44	0.133893251	media baja/mid-low
10	149	6.678619453	alta/high	751	2.285314345	media alta/mid-high
11	920	41.2371134	alta/high	6913	21.03645548	alta/high
12	0	0	nula	37	0.112592052	media baja/mid-low
13	0	0	nula	65	0.197796847	media baja/mid-low
14	35	1.568803227	media alta/mid-high	3420	10.4071572	alta/high
15	1	0.044822949	baja/low	33	0.100419938	baja/low
16	80	3.585835948	alta/high	769	2.340088856	media alta/mid-high
17	119	5.333930973	alta/high	4352	13.24325969	alta/high
18	3	0.134468848	baja/low	1	0.003043028	baja/low
19	4	0.179291797	baja/low	14	0.042602398	baja/low
20	2	0.089645899	baja/low	2	0.006086057	baja/low
21	5	0.224114747	media baja/mid-low	586	1.783214655	media alta/mid-high
22	23	1.030927835	media baja/mid-low	985	2.997382996	media alta/mid-high
23	20	0.896458987	media baja/mid-low	1904	5.793926115	media alta/mid-high

13	D. wallichi	ELC_CAT	GBfreq	GBpercentage	GB_quartile_classification	TotalCellsFreq	ELCmap_percentage	Quartile_classes_ELCmap
		1	0	0	nula	3	0.007188384	baja/low
		2	0	0	nula	42	0.10063737	baja/low
		3	0	0	nula	119	0.285139215	media baja/mid-low
		4	0	0	nula	958	2.295490487	media alta/mid-high
		5	1	1.851851852	baja/low	322	0.77155317	media baja/mid-low
		6	2	3.703703704	media baja/mid-low	5370	12.86720659	alta/high
		7	0	0	nula	63	0.150956055	media baja/mid-low
		8	5	9.259259259	media alta/mid-high	6814	16.32721522	alta/high
		9	0	0	nula	3202	7.672401399	alta/high
		10	16	29.62962963	alta/high	3854	9.234676762	alta/high
		11	0	0	nula	1	0.002396128	baja/low

12	0	0	nula	1266	3.033497867	media alta/mid-high
13	1	1.851851852	baja/low	1985	4.756313797	media alta/mid-high
14	1	1.851851852	baja/low	695	1.665308861	media alta/mid-high
15	0	0	nula	153	0.366607562	media baja/mid-low
16	0	0	nula	47	0.112618009	baja/low
17	1	1.851851852	baja/low	291	0.697273206	media baja/mid-low
18	2	3.703703704	media baja/mid-low	293	0.702065462	media baja/mid-low
19	0	0	nula	26	0.062299324	baja/low
20	3	5.555555556	media alta/mid-high	2927	7.013466239	media alta/mid-high
21	0	0	nula	4	0.009584511	baja/low
22	2	3.703703704	media baja/mid-low	2660	6.373700101	media alta/mid-high
23	3	5.555555556	media alta/mid-high	1035	2.479992332	media alta/mid-high
24	0	0	nula	221	0.529544256	media baja/mid-low
25	5	9.259259259	media alta/mid-high	4182	10.0206067	alta/high

Table 4S8: Genebank frequency of global yam priority CWR

ELC category	**Taxon**	D abyssinica	D antaly	D arachidna	D baya	D burkilliana	D cirrhosa	D hispida	D minutiflora	D praehensilis	D sagittifolia	D schimperiana	D transversa	D wallichii	Total frequency
1		2	13	0	0	0	0	3	0	26	0	5	2	0	51
2		0	1	0	3	0	0	9	0	57	0	13	7	0	90
3		183	2	0	0	0	0	15	0	1	0	6	0	0	207
4		0	1	0	4	0	2	0	2	243	0	18	33	0	303
5		2	0	0	0	3	1	1	0	185	6	17	33	1	249

6	0	2	0	4	0	0	0	0	9	0	3	0	2	20
7	32	5	1	0	0	9	5	0	16	1	0	24	0	93
8	0	0	0	11	0	10	10	21	4	0	1	53	5	115
9	229	0	3	5	0	2	0	10	17	0	0	0	0	266
10	21	0	4	1	0	0	1	8	13	0	0	149	16	213
11	3	0	0	1	0	0	2	0	72	0	0	920	0	998
12	79	0	4	0	0	14	1	7	0	0	0	0	0	105
13	0	15	1	0	0	2	2	2	9	10	0	0	1	42
14	5	4	0	1	75	8	0	1	150	3	0	35	1	283
15	0	0	0	0	3	6	46	4	6	0	0	1	0	66
16	1	0	11	7	0	0	18	0	3	22	0	80	0	142
17	0	0	0	4	4	3	1	0	6	2	5	119	1	145
18	0	1	5	7	24	4	0	10	0	304	53	3	2	413
19	3	0	0	1	0		0	11	1	3	31	4	0	54
20	0	1	0	38	0		0	59	2	1	58	2	3	164
21	2	0	0	4	2		0	1	3	0		5	0	17
22	4	0		0	2		2	0	3	10		23	2	46
23	19	0		0	13			3	0	8		20	3	66
24	0	0		0	5			0	14	33			0	52
25	2	71		0	0			82	34				5	194
26	0	10		0				26	2					38
27	0	17		0										17
Total	587	143	29	91	131	61	116	247	876	403	210	1513	42	

Table 4S9: Percentage Genebank frequency of the global yam priority CWR

Taxon / ELC category	D abyssinica	D antaly	D arachidna	D baya	D burkilliana	D cirrhosa	D hispida	D minutiflora	D praehensilis	D sagittifolia	D smilacifolia	D transversa	D wallichii	Total
1	0.33557	7.69231	0	0	0	0	2.12766	0	2.82302	0	2.33645	0.08965	0	15.4047
2	0	0.59172	0	3.22581	0	0	6.38298	0	6.18893	0	6.07477	0.31376	0	22.778
3	30.7047	1.18343	0	0	0	0	10.6383	0	0.10858	0	2.80374	0	0	45.4387
4	0	0.59172	0	4.30108	0	1.65289	0	0.73529	26.3844	0	8.41121	1.47916	0	43.5557
5	0.33557	0	0	0	2.23881	0.82645	0.70922	0	20.0869	1.45985	7.94393	1.47916	1.85185	36.9317
6	0	1.18343	0	4.30108	0	0	0	0	0.9772	0	1.40187	0	3.7037	11.5673
7	5.36913	2.95858	3.030303	0	0	7.43802	3.5461	0	1.73724	0.24331	0	1.07575	0	25.3984
8	0	0	0	11.828	0	8.26446	7.0922	7.72059	0.43431	0	0.46729	2.37562	9.25926	47.4417
9	38.4228	0	9.090909	5.37634	0	1.65289	0	3.67647	1.84582	0	0	0	0	60.0653
10	3.52349	0	12.12121	1.07527	0	0	0.70922	2.94118	1.41151	0	0	6.67862	29.6296	58.0901
11	0.50336	0	0	1.07527	0	0	1.41844	0	7.81759	0	0	41.2371	0	52.0518
12	13.255	0	12.12121	0	0	11.5702	0.70922	2.57353	0	0	0	0	0	40.2292
13	0	8.87574	3.030303	0	0	1.65289	1.41844	0.73529	0.9772	2.43309	0	0	1.85185	20.9748
14	0.83893	2.36686	0	1.07527	55.9701	6.61157	0	0.36765	16.2866	0.72993	0	1.5688	1.85185	87.6677
15	0	0	0	0	2.23881	4.95868	32.6241	1.47059	0.65147	0	0	0.04482	0	41.9885
16	0.16779	0	33.33333	7.52688	0	0	12.766	0	0.32573	5.3528	0	3.58584	0	63.0583
17	0	0	0	4.30108	2.98507	2.47934	0.70922	0	0.65147	0.48662	2.33645	5.33393	1.85185	21.135
18	0	0.59172	15.15152	7.52688	17.9104	3.30579	0	3.67647	0	73.9659	24.7664	0.13447	3.7037	150.733
19	0.50336	0	0	1.07527	0		0	4.04412	0.10858	0.72993	14.486	0.17929	0	21.1265
20	0	0.59172	0	40.8602	0		0	21.6912	0.21716	0.24331	27.1028	0.08965	5.55556	96.3516
21	0.33557	0	0	4.30108	1.49254		0	0.36765	0.32573	0		0.22411	0	7.04668
22	0.67114	0		0	1.49254		1.41844	0	0.32573	2.43309		1.03093	3.7037	11.0756
23	3.18792	0		0	9.70149			1.10294	0	1.94647		0.89646	5.55556	22.3908

24	0	0	0	3.73134	0	1.52009	8.0292	0	13.2806
25	0.33557	42.0118	0	0	30.1471	3.69164		9.25926	85.4454
26	0	5.91716	0		9.55882	0.21716			15.6931
27	0	10.0592	0						1116.92

Table 4S10: Frequency of ELC categories in protected area

	Taxon	ELC category	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8	Zone 9	Zone 10	Zone 11	Zone 12	Zone 13	Zone 14	Zone 15	Zone 16	Zone 17	Zone 18	Zone 19	Zone 20	Zone 21	Zone 22	Zone 23	Zone 24	Zone 25	Zone 26	Zone 27	Frequency in PA	Total frequency	Percentage frequency in PA
1	*Dioscorera abyssinica* Hochst. ex Kunth		8		3	9	3	2	44	5	13	39	7	18				18		5	3			11	3	1	4			196	1786	10.9742
2	*Dioscorera antaly* Jum. & H.Perrier		10	10	6	6	7	5	4	4			3		8	9	5				1	6	7				1	7	3	102	488	20.9016
3	*Dioscorera arachidna* Prain & Burkill					2	2	5	10	8	20	11	2	6	5		12	13	3	14	2	1	7							123	1021	12.047
4	*Dioscorera baya* De Wild		1	1	3	4	1	7	1	30	14	3	7	4	1	6	3	1	9	9	9	9	9	3	1	1		5	4	146	1010	14.4554
5	*Dioscorera burkilliana* J. Miege			2	1	1	11	7		1						17	12	2	22	22	14	2	7	8	14	14	12			169	937	18.0362
6	*Dioscorera cirrhosa* Lour		1	77	45	5	1		9	6	7	1	5		4	28	35		2	3										229	1314	17.4277

7	*Dioscorera hispida* Dennst.	2	1	9								2				1	15			3		1	4						38	1929	1.9699
8	*Dioscorera minutiflora* Engl								22	4				2		3	1							4		2	2		40	1643	2.4345
9	*Dioscorera praehensilis* Benth.	11	6	7	58	16	24	43	25	23	26	41	6		3		18	5	2	1		1	1		74	51	18		460	2195	20.9567
10	*Dioscorera sagittifolia* Pax	5	7		4	10		12	8	9	16	9	1	4	9		31	15	9	2	5		14	11	22				203	1247	16.279
11	*Dioscorera schimperiana* Hochst. ex Kunth	35	43	19	43	66	30	402	613	23	1	17	1	1			3	12	194	87	37								1627	2217	73.3874
12	*Dioscorera transversa* R. Br.		4		30	24		13	34	2	231	337		4	31		8	13	18	7		5	26	27					814	1515	53.7293
13	*Dioscorera wallichii* Hook.f.				5		2				13		11	14	7	8		6	16	7	20		9	6		6			130	1256	10.3503
	Total	73	151	93	167	141	82	538	756	115	341	430	47	43	110	79	110	87	292	136	80	37	76	66	112	76	32	7			

Table 4S11: Number of priority taxa and taxa population in protected areas

	Protected Area		D abyssinica	D antaly	D arachidna	D baya	brevipetiolata	D burkilliana	D calcicola	D cirrhosa	D decipiens	D glabra	D hamiltonii	D hispida	inopinata	D lanata	D mangenotiana	D minutiflora	D nummularia L	D oryzetorum	D pentaphylla	D praehensilis	D pynaertii	D sagittifolia	D schimperiana	D smilacifolia	D togoensis	D transversa	D wallichii	Total number of CWRs	Total number of occurrence data

1	Batavia (Cape York Peninsula Aboriginal Land)																											1		1	1
2	Bellbird																											1		1	1
3	Bellthorpe																											2		1	2
4	Blue Fig Creek																											1		1	1
5	Bruxner Park																											1		1	1
6	Buderim Forest Park																											2		1	2
7	Cat Tien											1																		1	1
8	Columbey																											1		1	1
9	Curramore Sanctuary																											3		1	3
10	Djelk																											9		1	9
11	Dong Phayayen-Khao Yai Forest Complex				2		2			3	2	2								1	1									7	13
12	Ecosystem and Relict Cultural Landscape of Lope-Okanda																	1								4				2	5
13	Fish River																											4		1	4
14	Girramay																											1		1	1
15	Great Barrier Reef Coast																											8		1	8
16	Great Sandy																											42		1	42
17	Kaanju Ngaachi Wenlock and Pascoe Rivers																											4		1	4

18	Kafa																								5					1	5
19	Kien Giang											2	3																	2	5
20	Kulla (McIlwraith Range) (Cape York Peninsula Aboriginal Land)																											2		1	2
21	Kutini-Payamu (Iron Range) (Cape York Peninsula Aboriginal Land)																											2		1	2
22	Lake Niassa and its Coastal Zone																					1								1	1
23	Lam Nam Kok											1																		1	1
24	Lamto Scientific Reserve		1					2										4				2					3			5	12
25	Luki																									2				1	2
26	Macalister Range																											3		1	3
27	Mandingalbay Yidinji																											5		1	5
28	Mefou																									2				1	2
29	Mines Road																											2		1	2
30	Mount Allyn																											3		1	3
31	Nerang																											1		1	1
32	Ngalba Bulal																											3		1	3
33	Niger-Niandan-Milo		7															1				4								3	12
34	Noosa																											17		1	17
35	North Pine Dam																											2		1	2

36	Oyala Thumotang (Cape York Peninsula Aboriginal Land)																											2		1	2
37	Palm Grove																											2		1	2
38	Parc National Pongara																	1												1	1
39	Phu Khat				2						1																			2	3
40	Port Stephens - Great Lakes																											1		1	1
41	Sangha Trinational					5		2									1					8			1	18				6	35
42	Sangha-Nouabale-Ndoki							1																		3				2	4
43	Sankarani-Fie		1																			1								2	2
44	Scarcies River Estuary																										1			1	1
45	Silver Plains																											2		1	2
46	Socotra Archipelago															6														1	6
47	Somerset-Wivenhoe Dams																											2		1	2
48	Spicers Peak																											2		1	2
49	Steve Irwin Wildlife Reserve																											1		1	1
50	Sugarloaf																											77		1	77
51	Tanjung Tampa													1																1	1
52	Tewantin																											3		1	3
53	The Hunter Lakes																											4		1	4

54	Three Parallel Rivers of Yunnan Protected Areas																				13								1	13
55	Tinkisso		1																										1	1
56	Uunguu																										12		1	12
57	Warddeken																										14		1	14
58	Western Ghats																				1							2	2	3
59	Wrattens																										5		1	5
60	Yangambi					18											23									13			3	54
			10	0	4	23	2	5	0	3	3	6	3	1	0	6	1	30	0	1	15	16	0	0	6	42	4	247	2	85	430
	Number of PA found		4	0	2	2	1	3	0	1	2	4	1	1	0	1	1	5	0	1	3	5	0	0	2	6	2	37	1		

Table 4S12: Global yam priority taxa in network of protected areas by country

	Protected Area	**Country**	**Designation**	**IUCN Category**	**Total number of CWRs**	**Total number of occurrence data**	**Priority CWR in Protected Area**
1	Batavia (Cape York Peninsula Aboriginal Land)	Australia	National Park Aboriginal	II	1	1	*Dioscorera transversa* R. Br.
2	Bellbird	Australia	Nature Refuge	VI	1	1	*Dioscorera transversa* R. Br.
3	Bellthorpe	Australia	National Park	II	1	2	*Dioscorera transversa* R. Br.
4	Blue Fig Creek	Australia	Nature Refuge	VI	1	1	*Dioscorera transversa* R. Br.
5	Bruxner Park	Australia	Flora Reserve	Ia	1	1	*Dioscorera transversa* R. Br.
6	Buderim Forest Park	Australia	Nature Refuge	VI	1	2	*Dioscorera transversa* R. Br.

7	Cat Tien	Vietnam	UNESCO-MAB Biosphere Reserve	Not Applicable	1	1	*Dioscorera glabra* Roxb.
8	Columbey	Australia	National Park	II	1	1	*Dioscorera transversa* R. Br.
9	Curramore Santuary	Australia	Nature Refuge	VI	1	3	*Dioscorera transversa* R. Br.
10	Djeik	Australia	Indigenous Protected Area	VI	1	9	*Dioscorera transversa* R. Br.
11	Dong Phayayen - Khao Yai Forest Complex	Thailand	World Heritage Site (natural or mixed)	Not Applicable	7	13	Dioscorera arachidna Prain & Burkill;Dioscorera brevipetiolata Prain & Burkill;Dioscorera cirrhosa Lour;Dioscorera decipiens Hook.f.;Dioscorera glabra Roxb.;Dioscorera oryzetorum Prain & Burkill;Dioscorera pentaphylla L.
12	Ecosystem and Relict Cultural Landscape of Lope - Okanda	Gabon	Site du Patrimoine Mondial (naturel ou mixte)	Not Applicable	2	5	*Dioscorera minutiflora* Engl;Dioscorera smilacifolia De Wild. & T. Durand
13	Fish River	Australia	NRS Addition - Gazettal in Progress	II	1	4	*Dioscorera transversa* R. Br.
14	Girramay	Australia	National Park	II	1	1	*Dioscorera transversa* R. Br.
15	Great Barrier Reef Coast	Australia	Marine Park	VI	1	8	*Dioscorera transversa* R. Br.
16	Great Sandy	Australia	UNESCO-MAB Biosphere Reserve	Not Applicable	1	42	*Dioscorera transversa* R. Br.
17	Kaanju Ngaachi Wenlock and Pascoe River	Australia	Indigenous Protected Area	V	1	4	*Dioscorera transversa* R. Br.
18	Kafa	Ethiopia	UNESCO-MAB Biosphere Reserve	Not Applicable	1	5	Dioscorera schimperiana Hochst. ex Kunth

19	Kien Giang	Vietnam	UNESCO-MAB Biosphere Reserve	Not Applicable	2	5	*Dioscorera glabra* Roxb.;Dioscorera hamiltonii Hook.f.
20	Kulla (Mcllwraith Range) (Cape York Peninsula Aborigal Land)	Australia	National Park Aboriginal	II	1	2	*Dioscorera transversa* R. Br.
21	Kutini- Payamu (Iron Range) (Cape York Peninsula Aborigal Land)	Australia	National Park Aboriginal	II	1	2	*Dioscorera transversa* R. Br.
22	Lake Niassa and its Coastal Zone	Mozambique	Ramsar Site, Wetland of International Importance	VI	1	1	*Dioscorera praehensilis* Benth.
23	Lam Nam Kok	Thailand	National Park	II	1	1	Dioscorera glabra Roxb
24	Lamto Scientific Reserve	Cote d'Ivoire	Reserve naturelle	Ia	5	12	*Dioscorera abyssinica* Hochst. ex Kunth;Dioscorera burkilliana J. Miege;Dioscorera minutiflora Engl;Dioscorera praehensilis Benth.;Dioscorera togoensis R. Knuth
25	Luki	Congo (the Democratic Republic of the)	Biosphere Reserve	Not Reported	1	2	*Dioscorera smilacifolia* De Wild. & T. Durand
26	Macalister Range	Australia	National Park	II	1	3	*Dioscorera transversa* R. Br.
27	Mandingalbay	Australia	Indigenous Protected Area	V	1	5	*Dioscorera transversa* R. Br.
28	Mefou	Cameroon	Parc National	II	1	2	*Dioscorera smilacifolia* De Wild. & T. Durand
29	Mines Road	Australia	Flora Reserve	Ia	1	2	*Dioscorera transversa* R. Br.
30	Mount Allyn	Australia	Flora Reserve	Ia	1	3	*Dioscorera transversa* R. Br.
31	Nerang	Australia	National Park	II	1	1	*Dioscorera minutiflora* Engl
32	Ngalba Bulal	Australia	National Park	II	1	3	*Dioscorera transversa* R. Br.

33	Niger - Niandan - Milo	Guinea	Ramsar Site, Wetland of International Importance	Not Reported	3	12	*Dioscorera abyssinica* Hochst. ex Kunth;Dioscorera minutiflora Engl;Dioscorera praehensilis Benth.
34	Noosa	Australia	UNESCO-MAB Biosphere Reserve	Not Applicable	1	17	*Dioscorera transversa* R. Br.
35	North Pine Dam	Australia	Nature Refuge	VI	1	2	*Dioscorera transversa* R. Br.
36	Oyala Thumotang (Cape York Peninsula Aboriginal Lang)	Australia	National Park Aboriginal	II	1	2	*Dioscorera transversa* R. Br.
37	Palm Grove	Australia	Nature Reserve	Ia	1	2	*Dioscorera transversa* R. Br.
38	Parc National Pongara	Gabon	Site Ramsar, Zone Humide dâ€™Importance Internationale	Not Reported	1	1	*Dioscorera minutiflora* Engl
39	Phu Khat	Thailand	Wildlife Sanctuary	Ia	2	3	*Dioscorera arachidna* Prain & Burkill;Dioscorera decipiens Hook.f.
40	Port Stephens - Great Lakes	Australia	Marine Park	VI	1	1	*Dioscorera transversa* R. Br.
41	Sanha Trinational	Congo (the);Cameroon ;Central African Republic (the)	Site du Patrimoine Mondial (naturel ou mixte)	Not Applicable	6	35	*Dioscorera baya* De Wild;Dioscorera burkilliana J. Miege;Dioscorera mangenotiana J. Miege;Dioscorera praehensilis Benth.;Dioscorera schimperiana Hochst. ex Kunth;Dioscorera smilacifolia De Wild. & T. Durand
42	Sangha - Nouabale - Ndoki	Congo (the)	Site Ramsar, Zone Humide dâ€™Importance Internationale	Not Reported	2	4	Dioscorera burkilliana J. Miege;Dioscorera smilacifolia De Wild.
43	Sankarani - Fie	Guinea	Ramsar Site, Wetland of International Importance	Not Reported	2	2	*Dioscorera abyssinica* Hochst. ex Kunth;Dioscorera praehensilis Benth
44	Scarcies River Estuary	Sierra Leone	Marine Protected Area	Not Reported	1	1	*Dioscorera togoensis* R. Knuth

45	Silver Plains	Australia	NRS Addition - Gazettal in Progress	II	1	2	*Dioscorera transversa* R. Br.
46	Socotra Archipelago	Yemen	World Heritage Site (natural or mixed)	Not Applicable	1	6	*Dioscorera lanata* Bail
47	Somerset - Wivenhoe Dams	Australia	Nature Refuge	VI	1	2	*Dioscorera transversa* R. Br.
48	Spicers Peak	Australia	Nature Refuge	VI	1	2	*Dioscorera transversa* R. Br.
49	Steve Irwin Wildlife Reserve	Australia	Nature Refuge	VI	1	1	*Dioscorera transversa* R. Br.
50	Sugerloaf	Australia	State Conservation Area	II	1	77	*Dioscorera transversa* R. Br.
51	Tanjung Tampa	Indonesia	Taman Wisata Alam	V	1	1	*Dioscorera hispida* Dennst.
52	Tewantin	Australia	National Park	II	1	3	*Dioscorera transversa* R. Br.
53	The Hunter Lakes	Australia	Flora Reserve	Ia	1	4	*Dioscorera transversa* R. Br.
54	Three Parallel Rivers of Yunnan Protected Areas	China	World Heritage Site (natural or mixed)	Not Applicable	1	13	*Dioscorera pentaphylla* L.
55	Tinkisso	Guinea	Ramsar Site, Wetland of International Importance	Not Reported	1	1	*Dioscorera abyssinica* Hochst. ex Kunth
56	Uunguu	Australia	Indigenous Protected Area	VI	1	12	*Dioscorera transversa* R. Br.
57	Warddeken	Australia	Indigenous Protected Area	VI	1	14	*Dioscorera transversa* R. Br.
58	Western Ghats	India	World Heritage Site (natural or mixed)	Not Applicable	2	3	*Dioscorera wallichii* Hook.f.
59	Wrattens	Australia	Conservation Park	III	1	5	*Dioscorera transversa* R. Br.

60	Yangambi	Congo (the Democratic Republic of the)	Biosphere Reserve	Ia	3	54	*Dioscorera baya* De Wild;Dioscorera minutiflora Engl;Dioscorera smilacifolia De Wild. & T. Durand

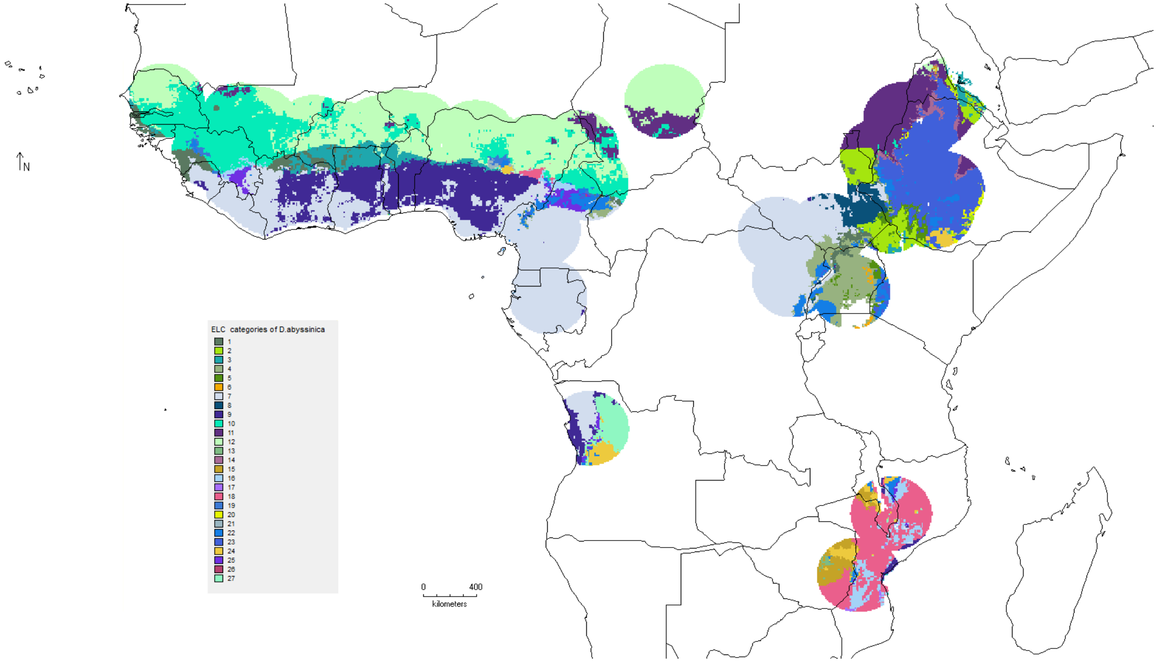


Fig. 4S1: ELC categories of *D. abyssinica*

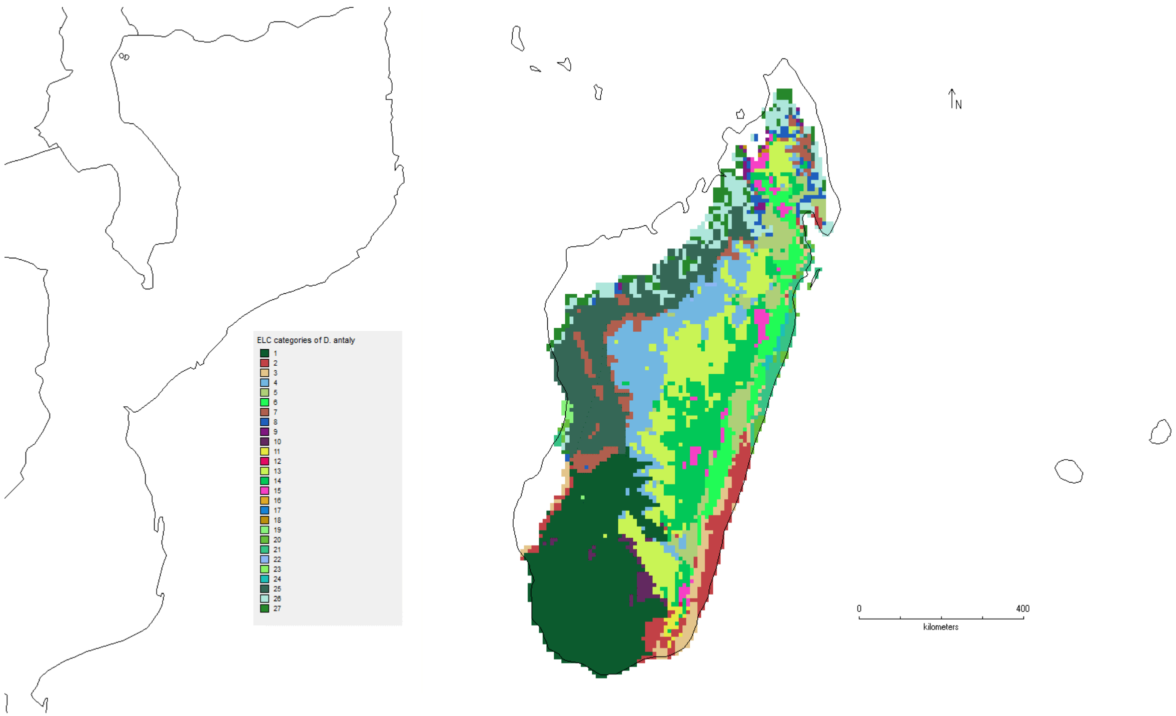


Fig. 4S2: ELC categories of *D. antaly*

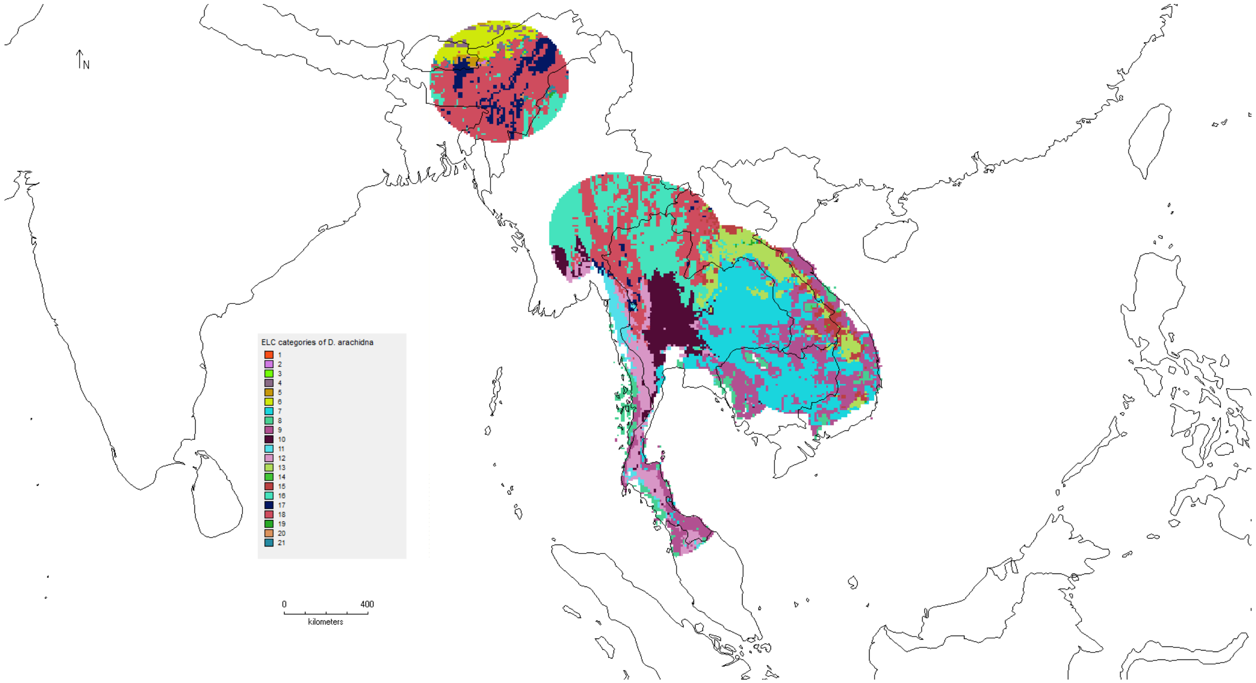


Fig. 4S3: ELC categories of *D. arachidna*

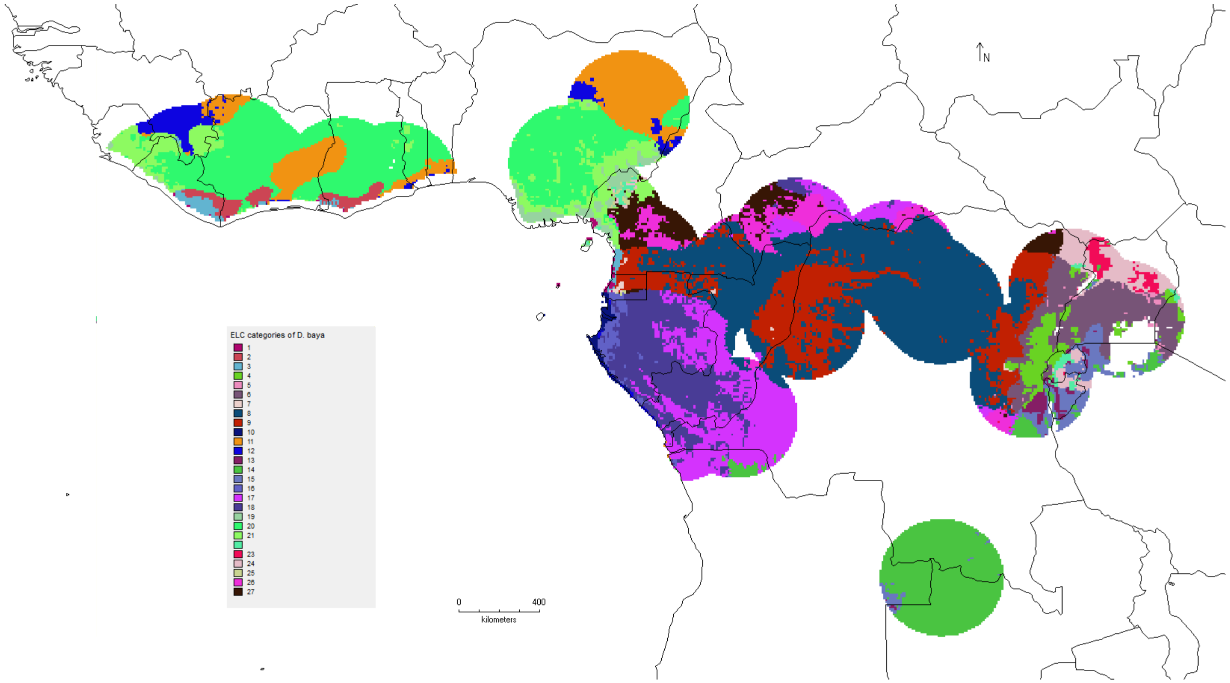


Fig. 4S4: ELC categories of *D. baya*

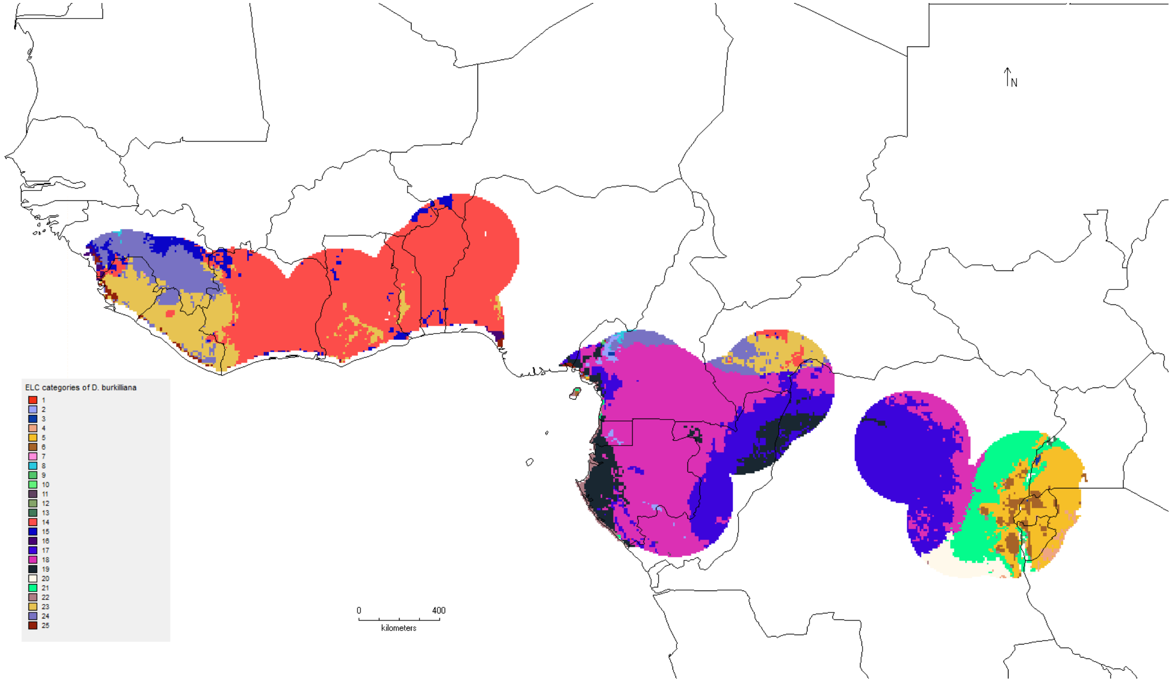


Fig. 4S5: ELC categories of *D. burkilliana*

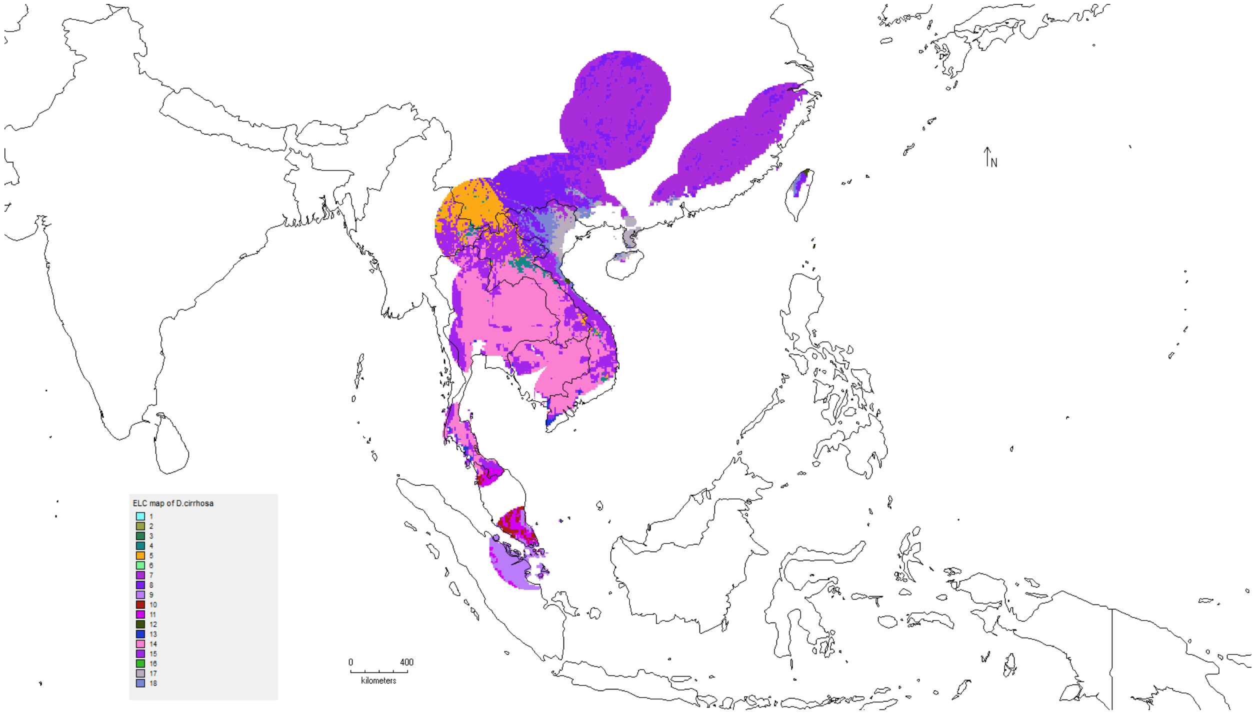


Fig. 4S6: ELC categories of *D. cirrhosa*

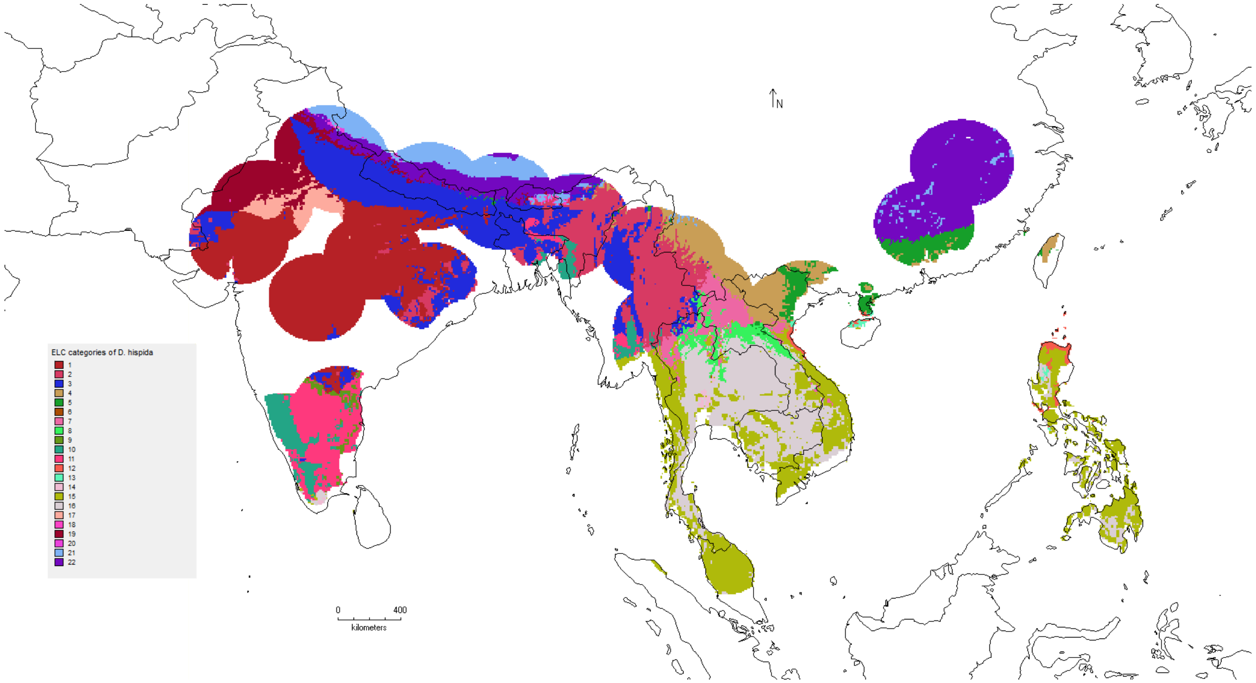


Fig. 4S7: ELC categories of *D. hispida*

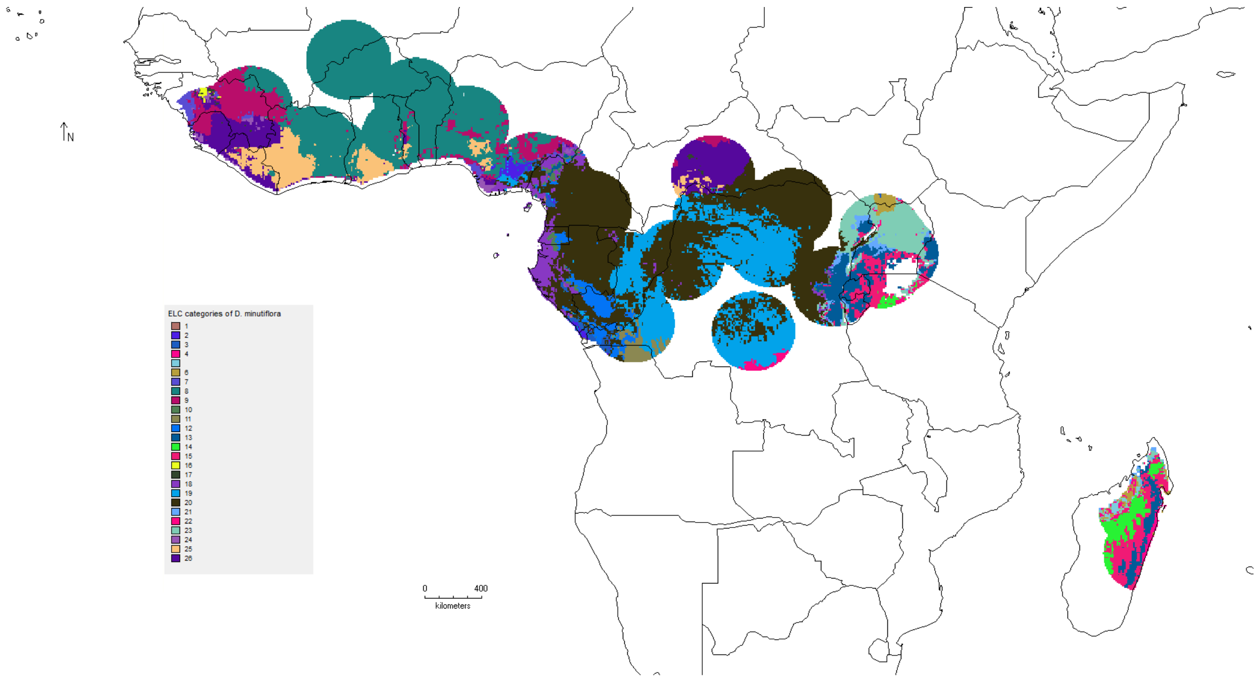


Fig. 4S8: ELC categories of *D. minutiflora*

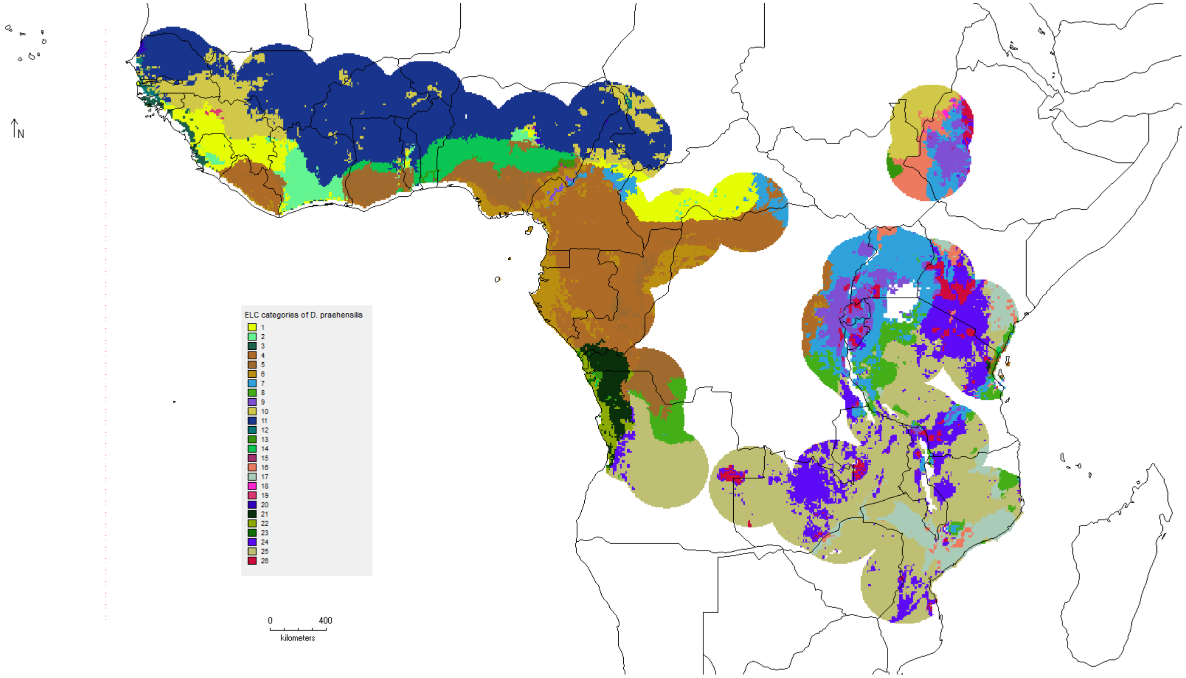


Fig. 4S9: ELC categories of *D. praehensilis*

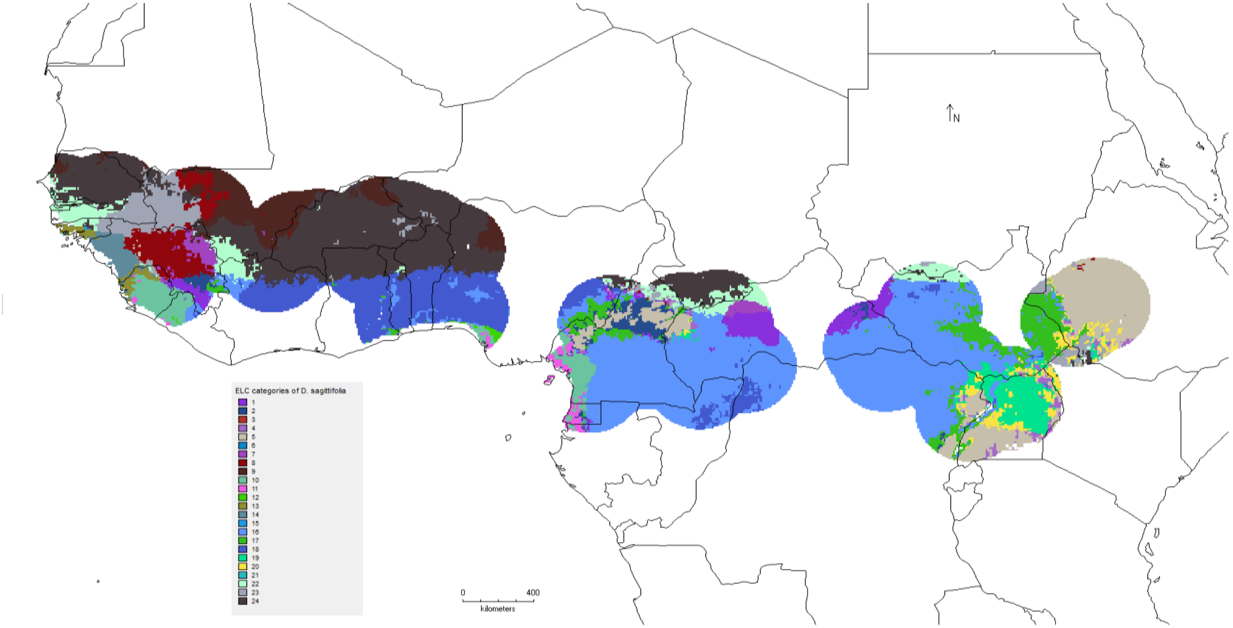


Fig. 4S10: ELC categories of *D. sagittifolia*

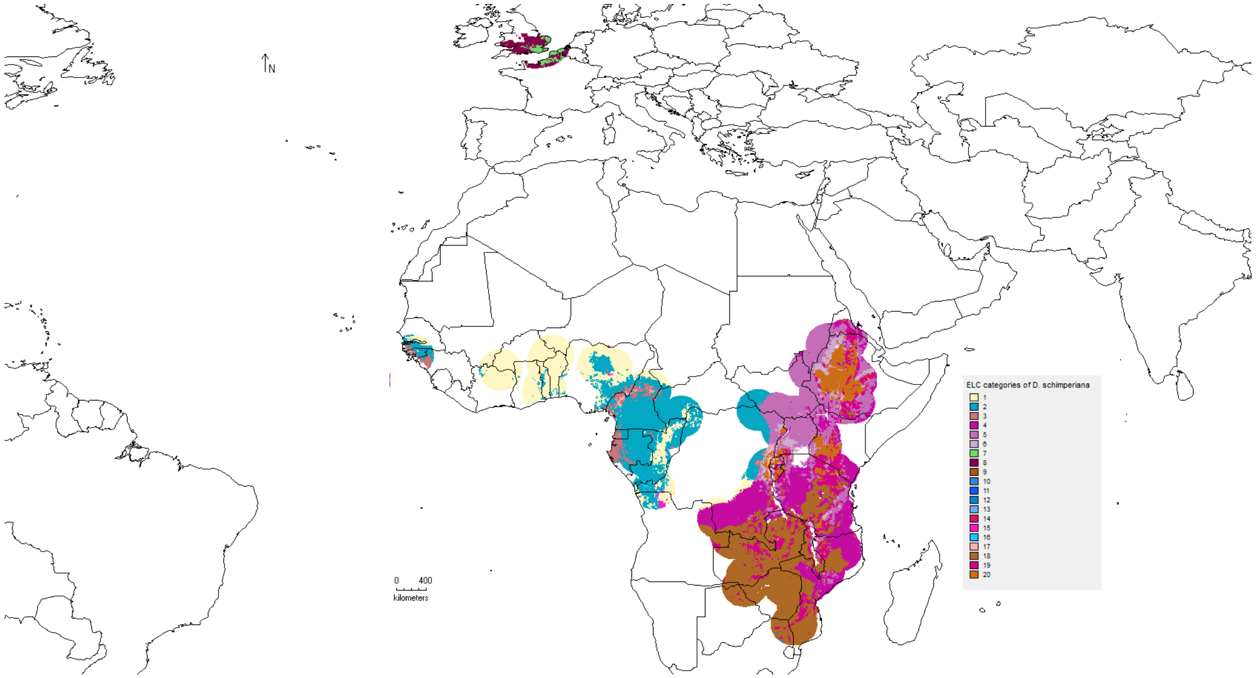


Fig. 4S11: ELC categories of *D.schimperiana*

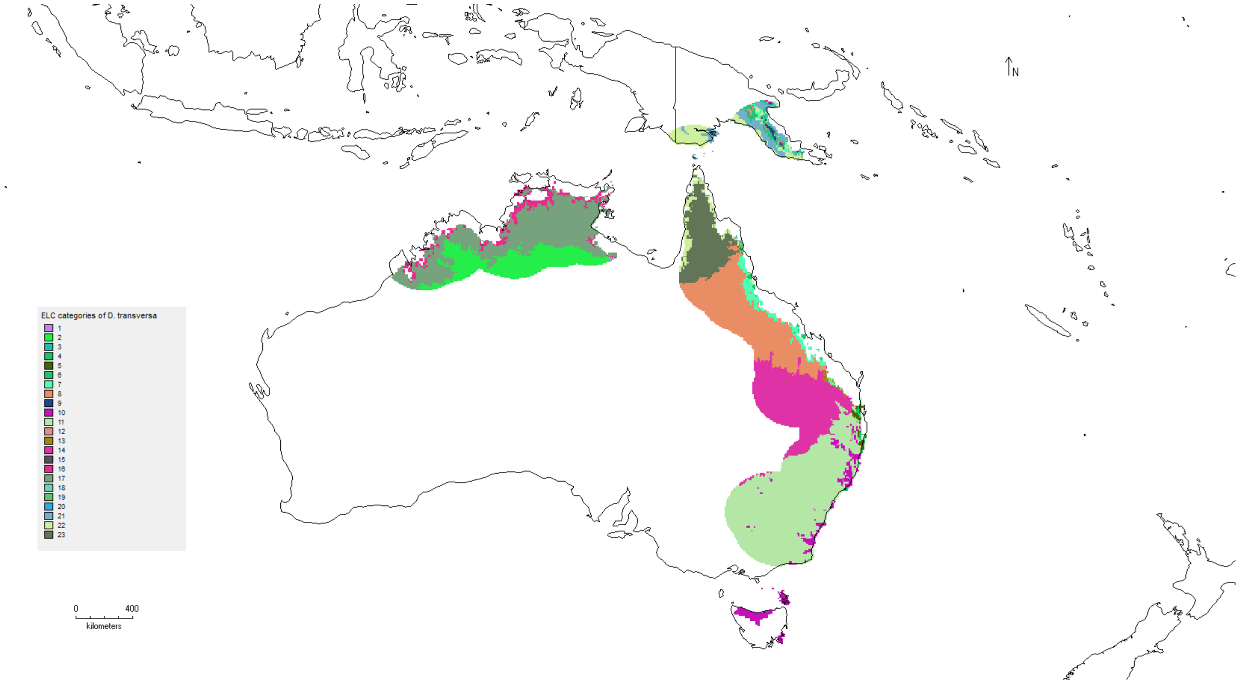


Fig. 4S12: ELC categories of *D.transversa*

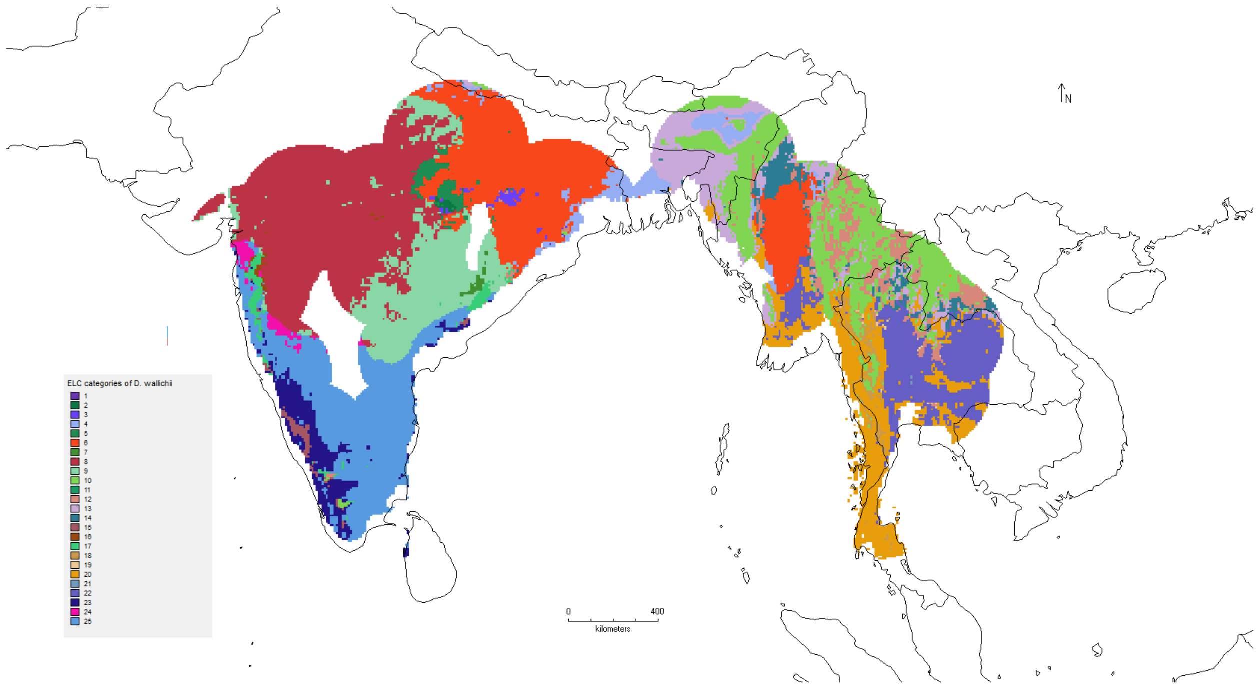


Fig. 4S13: ELC categories of *D.wallichi*

Table 5S1: Range change of the West African CWR

s/n	CWR		Current climate (Number of pixel)			SSP 245 (2050) (Number of pixel)					SSP 245 (2070) (Number of pixel)				
		Number of occurrence data	Total current area	Current suitable areas	Current non suitable areas	High impact areas	Areas outside of the realized niche	Low impact areas	New suitable areas	SSP 245 (2050) Species Range Change	High impact areas	Areas outside of the realized niche	Low impact areas	New suitable areas	SSP 245 (2070) Species Range Change

1	Cola acuminata	110	173998	1912	175910	373	153232	1482	20171	10.51	357	150859	1498	22544	11.6
2	Cola angustifolia	13	175205	705	175910	365	135707	318	38868	54.61	367	138372	316	36203	50.83
3	Cola attensis	25	175158	752	175910	38	158147	665	16408	21.77	34	156792	669	17763	23.78
4	Digitaria ciliaria	960	166803	9107	175910	3828	157362	5180	8888	0.56	3172	155565	5836	10685	0.27
5	Digitaria fuscescens	34	174879	1031	175910	131	141395	796	32936	31.82	126	138509	801	35822	34.62
6	Digitaria iburua	10	531577	170756	702333	16127	73451	25764	59916	0.26	15565	72765	26326	60602	0.26
7	Dioscorea alata	4	174944	966	175910	105	113013	792	61348	63.4	328	103519	569	70842	72.99
8	Dioscorea burkilliana	97	170764	5146	175910	1952	170071	3171	64	-0.37	1270	148444	3853	21691	3.97
9	Dioscorea cayenensis	246	171291	4619	175910	843	151219	3690	19506	4.04	722	152647	3811	18078	3.76
10	Dioscorea minutiflora	208	172672	3238	175910	740	157676	2447	14395	4.22	758	158050	2429	14021	4.1
11	Dioscorea praehensilis	425	171146	4764	175910	707	151949	3976	18626	3.76	618	157500	4065	13075	2.61
12	Dioscorea quartiniana	42	170240	5670	175910	1127	150296	4475	19360	3.22	1435	153098	4167	16558	2.67
13	Dioscorea sagittifolia	188	173204	2706	175910	602	159867	1968	11203	1.78	565	161976	2098	10619	3.72
14	Dioscorea sagittifolia var. lecardii	28	164689	11221	175910	2366	142450	8714	21728	1.73	2332	140608	8748	23570	1.89
15	Dioscorea sansibarensis	51	171375	3883	175258	894	150185	2989	21190	5.23	541	154679	3342	16696	4.16
16	Dioscorea smilacifolia	217	172083	3827	175910	745	154817	2952	16744	4.18	815	154131	2882	17430	4.34
17	Dioscorea togoensis	474	171527	3731	175258	563	153123	3168	18404	49.27	502	157410	3229	14117	3.65
18	Echinochloa crus-galli	5	159333	16577	175910	2120	101968	14266	56904	3.3	1425	93860	14961	65012	3.83
19	Echinochloa pyramidalis	656	169149	6761	175910	1798	155026	4835	13599	1.74	1309	154171	5324	14454	1.94
20	Eleusine africana	30	162759	13151	175910	2969	151599	10166	10524	0.57	2603	147372	10532	14751	0.92
21	Eleusine indica	674	166341	9294	175635	1656	142446	7528	23431	2.34	1497	144327	7687	21550	2.16
22	Eragrostis japonica	176	167004	8631	175635	4064	154052	2247	14698	1.23	1843	155029	6725	11464	1.11
23	Eragrostis pilosa	774	169278	6357	175635	2087	159608	4224	9142	1.11	4068	152804	2243	15946	1.87
24	Eragrostis unioloides	19	173537	2098	175635	940	117166	1078	55877	28.19	924	116186	1094	56857	26.66
25	Gossypium anomalum	35	171338	4297	175635	1082	148336	3214	22429	4.96	1056	138056	3240	32709	7.37
26	Gossypium barbadense	17	172282	3353	175635	633	95686	2718	76024	22.48	216	93387	3135	78323	23.29
27	Gossypium herbaceum var. acerifolium	8	123731	52179	175910	13435	84553	38391	38879	0.29	13301	84577	38525	38855	0.49
28	Ipomoea acanthocarpa	24	165943	9967	175910	2828	95050	7051	70329	6.77	2828	95050	7051	70329	6.77
29	Ipomoea alba	62	168981	6929	175910	968	136045	5829	32416	4.54	4859	110938	1938	57523	7.6

30	Ipomoea aquatica	679	168676	6959	175635	1910	147327	4928	20896	2.73	1811	152598	1920	20652	2.71
31	Ipomoea argentaurata	434	170223	4838	175061	1083	156962	3755	13261	2.52	937	158276	3901	11947	2.28
32	Ipomoea asarifolia	265	167518	8392	175910	1939	147768	6304	19247	2.06	1674	149175	6569	17840	1.93
33	Ipomoea barteri	61	174911	724	175635	138	164794	586	9543	12.99	187	169689	537	4648	6.16
34	Ipomoea blepharophylla	45	162546	13364	175910	2697	148163	10633	13765	0.83	2644	143684	10686	18244	1.17
35	Ipomoea coptica	137	172286	3624	175910	1551	150426	1950	21331	5.46	1468	143705	2033	28052	7.33
36	Ipomoea rubens	93	173908	2002	175910	1060	154636	898	18664	8.79	872	153675	1086	19625	9.37
37	Manihot carthagenensis subsp. glaziovii	24	171333	4577	175910	1873	83473	2562	87350	18.68	667	132154	3768	38669	8.3
38	Oryza barthi	2396	163505	12405	175910	4109	151796	8181	11172	0.57	3501	151419	8789	11549	0.65
39	Oryza brachyantha	93	163531	12379	175910	3686	154744	8575	8253	0.37	3312	154320	8949	8677	0.43
40	Oryza eichingeri	9	165993	9917	175910	4616	90771	5251	74620	7.06	5195	91663	4672	73728	6.91
41	Oryza longistaminata	1030	163319	12591	175910	4964	154736	7499	8059	0.23	4067	154151	8396	8644	0.36
42	Oryza puntata	78	170450	5460	175910	1226	141986	4176	27870	4.82	1160	136980	4242	32876	5.81
43	Panicum comorense	15	152496	23139	175635	1101	92424	9622	72111	3.07	1443	80650	9280	83885	3.56
44	Panicum repens	400	171196	4714	175910	888	148416	3609	22345	4.55	765	146650	3732	24111	4.95
45	Phoenix reclinata	333	171879	4031	172310	1021	153766	2831	17640	4.12	889	156601	2963	14805	3.45
46	Saccharum spontaneum subsp. aegyptiacum	4	172123	3787	175910	1045	139592	2681	31940	8.16	2845	150273	881	21259	4.86
47	Sorghum drummondii	5	146444	29466	175910	7408	106902	21913	39035	1.07	8170	84577	21151	61360	1.81
48	Sorghum purpureosericeum	3	113928	61330	175258	55509	56789	5821	57139	0.027	55268	58043	61947	56897	0.03
49	Vigna ambacensis	574	165812	10098	175910	2202	150238	7802	15016	1.27	1742	147720	8262	17534	1.56
50	Vigna filicaulis	399	115022	60236	175258	59721	99224	515	15798	-0.73	59882	99473	354	15549	-0.74
51	Vigna gracilis	544	170301	5609	175910	802	152260	4579	17617	2.99	724	151381	4657	18496	3.17
52	Vigna luteola	229	151744	23514	175258	9372	145116	14142	6628	-0.17	10637	144581	12877	7163	-0.15
53	Vigna marina	40	172786	3124	175910	408	140004	2460	32386	10.24	402	141878	2466	30512	9.64
54	Vigna multinervis	176	171484	4426	175910	1315	159341	2991	11611	2.33	1221	155687	3085	15265	3.17
55	Vigna nigritia	244	171373	4537	175910	588	142243	3841	28586	6.17	562	147905	3867	22924	4.93
56	Vigna oblongifolia	167	175313	597	175910	13	138138	549	36558	61.21	28	138528	534	36168	60.54
57	Vigna racemosa	1352	167977	7658	175635	1585	151018	6039	16419	2.19	1518	151918	6106	15519	1.83
58	Vigna reticulata	578	168504	7131	175635	3064	149631	4032	18334	2.14	2501	154966	4595	12999	1.47

59	Vigna unguiculata subsp. baoulensis	39	148254	27656	175910	13031	81108	14429	66690	1.94	13566	67421	13894	80377	2.42
60	Vigna unguiculata subsp. dekindtiana	333	163247	12663	175910	7148	151633	5362	11115	0.31	6565	149883	5945	12865	0.5
61	Vigna unguicul subsp letouzeyi	6	172480	3430	175910	22899	148955	615	2789	-5.86	22139	119864	1375	31880	2.84
62	Vigna unguiculata subsp unguiculata var spontanea	49	97237	78021	175258	20823	88934	27749	37752	0.22	22035	90440	26537	36246	0.18
63	Vigna unguiculata subsp. stenophylla	13	159572	16338	175910	3731	108893	12338	50296	2.85	2841	110368	13228	48821	2.81
	Total number of pixels		10738602	862365	11597367	310612	8567702	393312	1765843		308674	8480977	450378	1857875	

Table 5S1: Range change of the West African CWR (Continued)

s/n	CWR		Current climate (Number of pixel)			SSP 585 (2050) (Number of pixel)					SSP 585 (2070) (Number of pixel)				
		Number of occurrence data	Total current area	Current suitable areas	Current non suitable areas	High impact areas	Areas outside of the realized niche	Low impact areas	New suitable areas	SSP 585 (2050) Species Range Change	High impact areas	Areas outside of the realized niche	Low impact areas	New suitable areas	SSP 585 (2070) Species Range Change
1	Cola acuminata	110	173998	1912	175910	475	149671	1380	23732	12.16	653	156572	1202	16831	8.46
2	Cola angustifolia	13	175205	705	175910	361	139491	322	35084	49.25	668	156557	15	18018	24.61
3	Cola attensis	25	175158	752	175910	54	159245	649	15310	20.29	34	154335	669	20220	26.84
4	Digitaria ciliaria	960	166803	9107	175910	7204	140932	1804	25318	1.99	4147	157747	4861	8503	0.48
5	Digitaria fuscescens	34	174879	1031	175910	106	135409	821	38922	37.65	79	134368	848	39963	38.68
6	Digitaria iburua	10	531577	170756	702333	15284	69941	26607	63426	0.28	15745	74223	26146	59144	0.25
7	Dioscorea alata	4	174944	966	175910	72	140833	825	33528	34.63	115	141758	782	32603	33.63
8	Dioscorea burkilliana	97	170764	5146	175910	2233	157631	2890	12504	1.99	2119	156142	3004	13993	2.31
9	Dioscorea cayenensis	246	171291	4619	175910	1092	147044	3441	23681	4.89	1103	151823	2997	24130	4.99
10	Dioscorea minutiflora	208	172672	3238	175910	646	152067	2541	20004	5.98	798	160002	2389	12069	3.4
11	Dioscorea praehensilis	425	171146	4764	175910	822	151684	3861	18891	3.79	638	151236	4045	19339	3.93
12	Dioscorea quartiniana	42	170240	5670	175910	1297	146090	4305	23566	3.93	1727	147049	3875	22607	3.68

13	Dioscorea sagittifolia	188	173204	2706	175910	541	158975	2122	13620	4.83	643	160964	2020	11631	4.06
14	Dioscorea sagittifolia var. lecardii	28	164689	11221	175910	2790	143004	8290	21174	1.64	2233	141453	8847	22725	1.83
15	Dioscorea sansibarensis	51	171375	3883	175258	874	145764	3009	25611	6.37	1075	148258	2808	23117	5.68
16	Dioscorea smilacifolia	217	172083	3827	175910	792	155600	2905	15961	3.96	735	155122	2962	16439	4.1
17	Dioscorea togoensis	474	171527	3731	175258	648	151755	3083	19772	0.11	883	153656	2848	17871	4.55
18	Echinochloa crus-galli	5	159333	16577	175910	4157	112981	12229	45891	2.52	3841	106348	12545	52524	2.94
19	Echinochloa pyramidalis	656	169149	6761	175910	1892	154425	4741	14200	1.82	1962	152910	4671	15715	2.03
20	Eleusine africana	30	162759	13151	175910	4925	155474	8210	6649	0.13	5128	154641	8007	7482	0.18
21	Eleusine indica	674	166341	9294	175635	6776	153426	2408	12451	0.61	2503	141142	6681	24735	2.39
22	Eragrostis japonica	176	167004	8631	175635	2287	159740	4024	9010	0.78	2230	156764	6338	9729	0.87
23	Eragrostis pilosa	774	169278	6357	175635	2250	159472	4061	9278	1.12	2223	160994	4088	7756	0.87
24	Eragrostis unioloides	19	173537	2098	175635	1086	123652	932	49391	23.02	973	126858	1045	46185	21.55
25	Gossypium anomalum	35	171338	4297	175635	4290	120448	6	50317	10.71	1720	156438	2576	14327	2.93
26	Gossypium barbadense	17	172282	3353	175635	160	95419	3191	76291	22.71	633	95686	2718	76024	22.48
27	Gossypium herbaceum var. acerifolium	8	123731	52179	175910	14140	82038	37686	41394	0.52	14365	79691	37461	43741	0.56
28	Ipomoea acanthocarpa	24	165943	9967	175910	295	76451	9584	88928	8.89	3747	126143	6132	39236	3.56
29	Ipomoea alba	62	168981	6929	175910	961	133730	5836	34731	4.88	5905	123985	892	44476	5.57
30	Ipomoea aquatica	679	168676	6959	175635	2282	145722	4556	22501	2.91	2456	145074	4382	23149	2.97
31	Ipomoea argentaurata	434	170223	4838	175061	1714	156544	3124	13679	2.47	1908	155750	2930	14473	2.6
32	Ipomoea asarifolia	265	167518	8392	175910	2510	144735	5733	22280	2.36	3034	143939	5209	23076	2.39
33	Ipomoea barteri	61	174911	724	175635	124	162141	600	12196	16.67	122	163691	602	10646	14.54
34	Ipomoea blepharophylla	45	162546	13364	175910	5225	145723	8105	16205	0.82	5431	145454	7899	16474	0.83
35	Ipomoea coptica	137	172286	3624	175910	1444	150115	2057	21642	5.57	1288	149500	2213	22257	5.79
36	Ipomoea rubens	93	173908	2002	175910	1275	154889	683	18411	8.56	954	153234	1004	20066	9.55
37	Manihot carthagenensis subsp. glaziovii	24	171333	4577	175910	975	76886	3460	93937	20.31	2061	86738	2374	84085	17.92
38	Oryza barthi	2396	163505	12405	175910	4533	154139	7757	8829	0.35	4820	133859	7470	29109	1.96
39	Oryza brachyantha	93	163531	12379	175910	4335	157128	7926	5869	0.12	4457	158305	7804	4092	-0.03
40	Oryza eichingeri	9	165993	9917	175910	5436	90029	4431	75362	7.05	4627	89852	5240	75539	7.15

41	Oryza longistaminata	1030	163319	12591	175910	5433	156696	7030	6099	0.05	5368	157086	7095	5109	-0.02
42	Oryza puntata	78	170450	5460	175910	1233	135192	4169	34664	6.12	1427	143934	3975	25922	4.49
43	Panicum comorense	15	152496	23139	175635	4416	82881	6307	81654	3.34	3653	92705	7070	71830	0.35
44	Panicum repens	400	171196	4714	175910	1120	145256	3377	25505	5.17	1248	144308	3249	26453	5.35
45	Phoenix reclinata	333	171879	4031	172310	1441	153817	2411	17589	4.01	1238	152120	2614	19286	4.48
46	Saccharum spontaneum subsp. aegyptiacum	4	172123	3787	175910	1846	119895	1798	46985	11.92	1840	124522	1886	47010	11.93
47	Sorghum drummondii	5	146444	29466	175910	11653	105952	17668	39985	0.96	11166	102762	18155	43175	1.09
48	Sorghum purpureosericeum	3	113928	61330	175258	55669	61046	5661	52882	-0.05	55092	64117	6238	49811	-0.09
49	Vigna ambacensis	574	165812	10098	175910	2823	149289	7181	15965	1.3	1742	147720	8262	17534	1.56
50	Vigna filicaulis	399	115022	60236	175258	59882	99473	354	15549	-0.74	59871	100524	365	14498	-0.75
51	Vigna gracilis	544	170301	5609	175910	1221	150523	4160	19354	3.23	925	149320	4456	20557	0.33
52	Vigna luteola	229	151744	23514	175258	5416	147430	18098	4314	-0.05	6926	142961	16588	8783	0.08
53	Vigna marina	40	172786	3124	175910	451	142623	2417	29767	9.38	385	138717	2483	33673	1.07
54	Vigna multinervis	176	171484	4426	175910	1315	159341	2991	11611	2.33	1157	154345	3149	16607	4.95
55	Vigna nigritia	244	171373	4537	175910	562	147905	3867	22924	4.93	1254	145408	28596	23105	6.8
56	Vigna oblongifolia	167	175313	597	175910	13	138138	549	36558	61.21	85	140094	477	34602	57.82
57	Vigna racemosa	1352	167977	7658	175635	1518	151918	6106	15519	1.83	2127	151018	5497	16419	1.87
58	Vigna reticulata	578	168504	7131	175635	2826	152860	4270	15105	1.72	3133	151305	3963	16660	1.9
59	Vigna unguiculata subsp. baoulensis	39	148254	27656	175910	12481	81954	14979	65844	1.93	12481	81954	14979	65844	1.93
60	Vigna unguiculata subsp. dekindtiana	333	163247	12663	175910	4603	123982	7907	38766	2.7	4314	108161	8196	54587	3.97
61	Vigna unguicul subsp letouzeyi	6	172480	3430	175910	22139	119864	1375	31880	2.84	20590	135554	2924	16190	-1.28
62	Vigna unguiculata subsp. unguiculata var. spontanea	49	97237	78021	175258	19765	92920	28807	33766	0.81	18876	99649	29696	27037	0.1
63	Vigna unguiculata subsp. stenophylla	13	159572	16338	175910	5452	123133	10617	36056	1.87	5452	123133	10617	36056	1.87
	Total number of pixels		10738602	862365	11597367	331641	8452531	372294	1877887		330133	8559678	401129	1774847	

Table 5S2: Taxa used for species distribution modelling and criteria for validation.

s/n	Taxon	Number of occurrence records	ATAUC	STAUC	Threshold	Number of pixels with STAUC > 0	Number of pixels with STAUC < 0	ASD15 (%)	Valid	Remark
1	Cola acuminata (P. Beauv.) Schott & Endl.	110	0.975	0.018	0.0481	3232	697550	0.4633	Yes	SDM
2	Cola altissima Engl.	NA	NA	NA	NA	NA	NA	NA	NA	NA
3	Cola angustifolia K. Schum.	13	0.998	0.002	0.4395	1943	698839	0.278	Yes	SDM
4	Cola argentea Mast.	NA	NA	NA	NA	NA	NA	NA	NA	NA
5	Cola attiensis Aubrev. & Pellegr.	25	0.977	0.017	0.196	4081	696701	0.5857	Yes	SDM
6	Digitaria barbinodis Henrard	10	0.868	0.173	0.8971	169053	531729	31.793	No	SDM
7	Digitaria cillaria (Retz.) Koeler	960	0.926	0.015	0.2564	34751	666031	5.2176	Yes	SDM
8	Digitaria fuscenscens (J. Presl) Henrard	34	0.949	0.03	0.1248	4753	696029	0.6828	Yes	SDM
9	Digitaria iburua Stapf	10	0.916	0.081	0.4019	73509	627273	11.7188	Yes	SDM
10	Dioscorea abyssinica Hochst. Ex Kunth	1	NA	NA	NA	NA	NA	NA	NA	CA50
11	Dioscorea alata L.	4	0.932	0.038	0.6785	966	174944	0.5522	Yes	CA50
12	Dioscorea baya De Wild.	2	NA	NA	NA	NA	NA	NA	NA	CA50
13	Dioscorea bulbifera L.	9	NA	NA	NA	NA	NA	NA	NA	CA50
14	Dioscorea burkilliana J. Miege	97	0.973	0.023	0.1472	10373	690409	1.5024	Yes	SDM
15	Dioscorea cayenensis Lam.	246	0.962	0.014	0.1558	19214	681568	2.819	Yes	SDM
16	Dioscorea minutiflora Engl.	208	0.972	0.019	0.1665	12885	687897	1.8731	Yes	SDM
17	Dioscorea praehensilis Benth.	425	0.953	0.013	0.2167	21516	679266	3.1675	Yes	SDM
18	Dioscorea quartiniana A. Rich.	42	0.953	0.027	0.2941	1943	698839	0.278	Yes	SDM
19	Dioscorea sagittifolia Pax	188	0.988	0.004	0.2722	9384	691400	1.3572	Yes	SDM
20	Dioscorea sagittifolia var. lecardii (De Wild.) Nkounkou	28	0.905	0.054	0.5197	45738	655044	6.9824	Yes	SDM
21	Dioscorea sansibarensis Pax	51	0.958	0.043	0.1071	11534	689248	1.6734	Yes	SDM
22	Dioscorea schimperiana Hochst. ex Kunth	7	0.733	0.185	0.5	140631	560151	25.1059	No	CA50
23	Dioscorea smilacifolia De Wild. & T. Durand	217	0.973	0.01	0.1989	15025	685757	2.1908	Yes	SDM

24	Dioscorea togoensis R. Knuth	474	0.969	0.01	0.1834	13144	687638	1.9114	Yes	SDM
25	Echinochloa colonum (L.) Link	NA	NA	NA	NA	NA	NA	NA	NA	NA
26	Echinochloa crus- galli (L.) P. Beauv.	5	0.943	0.039	0.6875	56471	644311	8.7645	Yes	CA50
27	Echinochloa crus- pavonis (Kunth) Schult	NA	NA	NA	NA	NA	NA	NA	NA	NA
28	Echinochloa frumentacea Link	NA	NA	NA	NA	NA	NA	NA	NA	NA
29	Echinochloa pyramidalis (Lam.) Hitchc. & Chase	656	0.939	0.015	0.1551	30311	670471	4.5208	Yes	SDM
30	Eleusine africana Kenn - O'Byme	30	0.876	0.104	0.4231	31898	668884	4.7688	Yes	SDM
31	Eleusine coracana subsp. coracana (L.) Gaertn.	NA	NA	NA	NA	NA	NA	NA	NA	NA
32	Eleusine indica (L.) Gaertn.	674	0.922	0.01	0.2739	52504	648278	8.0989	Yes	SDM
33	Eragrostis japonica (Thunb.) Trin.	176	0.922	0.031	0.2047	51154	649628	7.8743	Yes	SDM
34	Eragrostis pilosa (L.) P. Beauv.	774	0.935	0.012	0.1711	28928	671854	4.3056	Yes	SDM
35	Eragrostis prolifera (Sw.) Steud.	NA	NA	NA	NA	NA	NA	NA	NA	NA
36	Eragrotis unioloides (Retz.) Nees ex Steud.	19	0.987	0.011	0.053	7376	693406	1.0637	Yes	SDM
37	Gossypium anomalum Wawra	35	0.957	0.034	0.1785	19356	681426	2.84051	Yes	SDM
38	Gossypium barbadense Linn.	17	0.917	0.106	0.1367	19848	680934	2.9148	Yes	SDM
39	Gossypium herbaceum var. acerifolium (Guill. & Perr.) A. Chev.	8	0.719	0.083	0.7014	245783	454999	54.0183	Yes	CA50
40	Hordeum bulbosum L	NA	NA	NA	NA	NA	NA	NA	NA	NA
41	Hordeum vulgare subsp. Spontaneum L.	NA	NA	NA	NA	NA	NA	NA	NA	NA
42	Ipomoea acanthocarpa (Choisy) Hochst. ex Schweinf. & Asch.	24	0.923	0.046	0.3756	37641	663141	5.6761	Yes	SDM
43	Ipomoea alba L.	62	0.925	0.074	0.2408	15450	685332	2.2543	Yes	SDM
44	Ipomoea aquatica Forssk.	679	0.931	0.013	0.2091	38428	662354	5.8017	Yes	SDM
45	Ipomoea argentaurata Hallier f.	434	0.957	0.008	0.1942	26834	673948	3.9816	Yes	SDM
46	Ipomoea asarifolia (Desr.) Roem. & Schult.	265	0.941	0.014	0.2177	32654	668128	4.8873	Yes	SDM
47	Ipomoea barteri Baker	61	0.974	0.027	0.5225	3322	697460	0.4762	Yes	SDM
48	Ipomoea blepharophylla Hallier f.	45	0.941	0.014	0.3337	34683	666099	5.2068	Yes	SDM
49	Ipomoea chrysochaetia Hallier f.	13	0.909	0.048	0.4072	79275	621507	12.7552	No	SDM

50	Ipomoea coptica (L.) Roth ex Roem. & Schult.	137	0.96	0.01	0.1581	14509	686273	2.1141	Yes	SDM
51	Ipomoea intrapilosa Rose	NA	NA	NA	NA	NA	NA	NA	NA	NA
52	Ipomoea ochracea (Lindl.) Sweet	6	NA	NA	NA	NA	NA	NA	NA	CA50
53	Ipomoea prismatosyphon Welw.	NA	NA	NA	NA	NA	NA	NA	NA	NA
54	Ipomoea rubens Choisy	93	0.977	0.024	0.2103	8407	692375	1.2142	Yes	SDM
55	Manihot carthagenesis (Jacq.) Mull. Arg.	NA	NA	NA	NA	NA	NA	NA	NA	NA
56	Manihot carthagenesis subsp. glaziovii (Mull. Arg.) Allem	24	0.93	0.067	0.3619	6304	694478	0.9077	Yes	SDM
57	Manihot dichotoma Ule	1	NA	NA	NA	NA	NA	NA	NA	CA50
58	Manihot esculenta subsp. flabellifolia Crantz	NA	NA	NA	NA	NA	NA	NA	NA	NA
59	Manihot esculenta subsp. peruviana Crantz	NA	NA	NA	NA	NA	NA	NA	NA	NA
60	Oryza barthi A. Chev.	2396	0.927	0.008	0.189	46254	654528	7.0667	Yes	SDM
61	Oryza brachyantha A. Chev. & Roeehr.	93	0.936	0.056	0.2354	27678	673104	4.1119	Yes	SDM
62	Oryza eichingeri Peter	9	0.955	0.065	0.7222	27945	672837	4.1533	Yes	CA50
63	Oryza glaberrima Steud.	3594	0.896	0.004	0.2912	67381	633401	10.6379	No	SDM
64	Oryza longistaminata A. Chev. & Roehr.	1030	0.924	0.009	0.1973	54295	646487	8.3984	Yes	SDM
65	Oryza puntata Kotschy ex Steud.	78	0.941	0.32	0.2173	20072	680710	2.9486	Yes	SDM
66	Panicum comorense Mez	15	0.935	0.079	0.2788	31734	669048	4.7431	Yes	SDM
67	Panicum repens L.	400	0.951	0.011	0.1438	15447	685335	2.2539	Yes	SDM
68	Phaseolus lunatus Linn	NA	NA	NA	NA	NA	NA	NA	NA	NA
69	Phaseolus vulgaris subsp. abarigineus L.	NA	NA	NA	NA	NA	NA	NA	NA	NA
70	Phaseolus vulgaris var. abarigineus L.	NA	NA	NA	NA	NA	NA	NA	NA	NA
71	Phoenix reclinata Jacq.	333	0.966	0.011	0.2172	13722	687060	1.9972	Yes	SDM
72	Saccharum spontaneum subsp. aegyptiacum (Willd.) Hack.	4	0.958	0.051	0.8875	11970	688812	1.7377	Yes	CA50
73	Saccharum spontaneum subsp. spontaneum L.	NA	NA	NA	NA	NA	NA	NA	NA	NA
74	Sorghum bicolor subsp. Verticilliflorum (L.) Moench	NA	NA	NA	NA	NA	NA	NA	NA	NA

75	Sorghum drummodii (Neee ex A. Rich.) Millsp. & Chase	5	0.965	0.027	0.6176	43309	657473	6.5871	Yes	CA50
76	Sorghum purpurreosericeum (Hoch. Ex A. Rich) Schweinf. & Asch.	3	0.961	0.026	0.92	14881	685901	2.16955	Yes	CA50
77	Sorghum virgatum (Hack.) Stapf	NA	NA	NA	NA	NA	NA	NA	NA	NA
78	Triticum turgidum L.	2	NA	NA	NA	NA	NA	NA	NA	CA50
79	Triticum turgidum subsp. durum (Desf.) Husn.	NA	NA	NA	NA	NA	NA	NA	NA	NA
80	Vigna ambacensis Welw. ex Bak.	574	0.938	0.017	0.2418	44345	656437	6.7554	Yes	SDM
81	Vigna desmodiodes Wilczek	17	0.856	0.067	0.4867	150967	549815	27.4577	No	SDM
82	Vigna filicaulis Hepper	399	0.957	0.012	0.186	30353	670429	4.5273	Yes	SDM
83	Vigna gracilis (Guill. & Perr.) Hook. f.	544	0.947	0.011	0.1881	27151	673631	4.0305	Yes	SDM
84	Vigna luteola (Jacq.) Benth.	229	0.96	0.021	0.152	11231	689551	1.6287	Yes	SDM
85	Vigna macrorrhyncha (Harms) Milne - Redhead	NA	NA	NA	NA	NA	NA	NA	NA	NA
86	Vigna marina (Burm.) Merill	40	0.963	0.029	0.0799	12433	688349	1.8062	Yes	SDM
87	Vigna multinervis Hutch. & Dalz.	176	0.966	0.014	0.1546	13072	687708	1.9008	Yes	SDM
88	Vigna nigritia Hook. f.	244	0.942	0.033	0.1516	13121	687661	1.908	Yes	SDM
89	Vigna oblongifolia A. Rich.	167	0.948	0.089	0.0042	1111	699671	0.1587	Yes	SDM
90	Vigna racemosa (G. Don) Hutch. & Dalz.	1352	0.936	0.008	0.2736	42386	658396	6.4377	Yes	SDM
91	Vigna reticulata Hook. f.	578	0.949	0.013	0.1991	34469	666313	5.173	Yes	SDM
92	Vigna unguiculata subsp. aduensis (L.) Pasquet	NA	NA	NA	NA	NA	NA	NA	NA	NA
93	Vigna unguiculata subsp. alba (G.Don) Pasquet	NA	NA	NA	NA	NA	NA	NA	NA	NA
94	Vigna unguiculata subsp. baoulensis (A.Chev.) Pasquet	39	0.953	0.027	0.382	17413	683369	2.5481	Yes	SDM
95	Vigna unguiculata subsp. burundiensis Pasquet	NA	NA	NA	NA	NA	NA	NA	NA	NA
96	Vigna unguiculata subsp. dekindtiana (Harms) Verdc.	333	0.94	0.016	0.21193	29812	670970	4.4431	Yes	SDM
97	Vigna unguiculata subsp. letouzeyi Pasquet	6	0.974	0.038	0.2645	32307	668475	4.8329	Yes	CA50
98	Vigna unguiculata subsp. pawekiae Pasquet	2	NA	NA	NA	NA	NA	NA	NA	CA50

99	Vigna unguiculata subsp. pubescens (R.Wilczek) Pasquet	2	NA	NA	NA	NA	NA	NA	NA	CA50
100	Vigna unguiculata subsp. stenophylla (Harv.) Marechal & al.	13	0.906	0.042	0.3613	62843	637939	9.8509	Yes	SDM
101	Vigna unguiculata subsp. tenuis (E.Mey) Marechal & al.	NA	NA	NA	NA	NA	NA	NA	NA	NA
102	Vigna unguiculata subsp. unguiculata var. spontanea (Schweinf.) Pasquet	49	0.943	0.023	0.2189	22318	678464	3.2894	Yes	SDM

Table 5S3: Magnitude of range shift for the West African priority CWR

s/n	CWR	Number of occurrence data	Current climate (Number of pixel)	SSP 245 (2050)			SSP 245 (2070)			SSP 585 (2050)			SSP 585 (2070)		
				Conraction	Occupied	Expansion	Conraction	Occupied	Expansion	Conraction	Occupied	Expansion	Conraction	Occupied	Expansion
1	Cola acuminata	110	173998	0.21	0.047	11.59	0.21	0.86	12.96	0.27	0.79	13.64	0.38	0.69	9.67
2	Cola angustifolia	13	175205	0.208	0.18	22.18	0.21	0.18	20.66	0.21	0.18	2.04	0.38	0.01	10.28
3	Cola attensis	25	175158	0.02	0.38	9.37	0.02	0.38	10.14	0.03	0.37	8.74	0.01	0.38	11.54
4	Digitaria ciliaria	960	166803	2.29	3.11	5.33	1.9	3.5	6.41	4.32	1.08	15.18	2.49	2.91	5.1
5	Digitaria fuscescens	34	174879	0.07	0.46	18.33	0.07	0.46	20.48	0.06	0.47	22.26	0.05	0.48	22.85
6	Digitaria iburua	10	531577	3.03	4.85	11.27	2.93	4.95	11.4	2.88	5	11.93	2.96	4.92	11.13
7	Dioscorea alata	4	174944	0.06	0.45	35.07	0.19	0.33	40.49	0.04	0.47	19.16	0.07	0.45	18.64
8	Dioscorea burkilliana	97	170764	1.14	1.86	1.86	0.74	2.26	12.7	1.31	1.69	7.32	1.24	1.76	8.19
9	Dioscorea cayenensis	246	171291	0.49	21.46	11.39	0.42	2.22	10.55	0.64	2	13.83	0.64	1.75	14.09
10	Dioscorea minutiflora	208	172672	0.43	1.42	8.34	0.44	1.41	8.12	0.37	1.47	11.58	0.46	1.38	6.99
11	Dioscorea praehensilis	425	171146	0.41	2.32	10.88	0.36	2.38	7.64	0.48	2.26	11.04	0.37	2.36	11.3

12	Dioscorea quartiniana	42	170240	0.66	2.63	11.37	0.84	2.45	9.73	0.76	2.53	12.84	1.01	2.28	13.28
13	Dioscorea sagittifolia	188	173204	0.35	1.14	6.47	3.26	1.21	6.13	0.31	1.23	7.86	0.37	1.17	6.72
14	Dioscorea sagittifolia var. lecardii	28	164689	1.44	5.29	13.19	1.42	5.31	1.43	1.69	5.03	12.86	1.36	5.37	13.8
15	Dioscorea sansibarensis	51	171375	0.52	1.74	12.36	0.32	1.95	9.74	0.51	1.76	14.94	0.63	1.64	13.49
16	Dioscorea smilacifolia	217	172083	0.43	1.72	9.73	0.47	1.67	10.13	0.46	1.69	9.28	0.43	1.72	9.55
17	Dioscorea togoensis	474	171527	0.32	1.85	10.73	0.29	1.88	8.23	0.38	1.8	11.53	0.51	1.66	10.42
18	Echinochloa crus-galli	5	159333	1.33	8.95	35.71	0.89	9.39	40.8	2.61	7.68	28.8	2.41	7.87	32.96
19	Echinochloa pyramidalis	656	169149	1.06	2.86	8.04	0.77	3.15	8.55	1.12	2.8	8.39	1.16	2.76	9.29
20	Eleusine africana	30	162759	1.82	6.23	6.47	1.6	6.47	9.06	3.03	5.04	4.09	3.15	4.92	4.6
21	Eleusine indica	674	166341	1	4.53	14.09	0.9	4.62	12.96	4.07	1.45	7.49	1.5	4.02	14.87
22	Eragrostis japonica	176	167004	2.43	1.35	8.8	1.1	4.03	6.86	1.37	2.41	5.4	1.34	3.8	5.83
23	Eragrostis pilosa	774	169278	1.23	2.5	5.4	2.4	1.33	9.42	1.33	2.4	5.48	1.31	2.41	4.58
24	Eragrostis unioloides	19	173537	0.54	0.62	32.2	0.53	0.63	32.76	0.63	0.54	28.46	0.56	0.6	26.61
25	Gossypium anomalum	35	171338	0.63	1.88	13.09	0.62	1.9	19.09	2.5	0.004	29.37	1	1.5	8.36
26	Gossypium barbadense	17	172282	0.37	1.58	44.13	0.13	1.82	45.46	0.09	1.85	44.28	0.36	1.58	44.13
27	Gossypium herbaceum var. acerifolium	8	123731	10.86	31.03	31.42	10.75	31.14	31.4	11.43	30.46	33.45	11.61	30.28	35.35
28	Ipomoea acanthocarpa	24	165943	1.7	4.25	4.25	1.7	4.25	42.38	0.18	5.78	53.59	2.26	3.7	23.64
29	Ipomoea alba	62	168981	0.52	3.45	19.18	2.88	1.15	34.04	0.57	3.45	20.55	0.35	0.53	26.32
30	Ipomoea aquatica	679	168676	1.13	2.92	12.39	1.07	1.14	12.24	1.35	2.7	1.33	1.46	2.6	13.72
31	Ipomoea argentaurata	434	170223	0.64	2.21	7.8	0.55	2.29	7.02	1	1.84	8.04	1.12	1.72	8.5
32	Ipomoea asarifolia	265	167518	1.16	3.76	11.49	1	3.92	10.65	1.5	3.42	13.3	1.81	3.1	13.78
33	Ipomoea barteri	61	174911	0.08	0.34	5.46	0.11	0.31	2.66	0.07	0.34	6.97	0.07	0.34	6.09
34	Ipomoea blepharophylla	45	162546	1.66	6.54	8.47	1.63	6.57	11.22	3.21	4.99	9.97	3.34	4.9	10.13
35	Ipomoea coptica	137	172286	0.9	1.13	12.38	0.85	1.18	16.28	0.84	1.19	12.56	0.75	1.28	12.92

36	Ipomoea rubens	93	173908	6.1	5.16	10.73	0.5	0.62	11.28	0.73	0.39	10.59	0.55	0.58	11.54
37	Manihot carthagenensis subsp. glaziovii	24	171333	1.1	1.5	51	0.39	2.2	22.57	0.57	2.02	54.83	1.2	1.39	49.08
38	Oryza barthi	2396	163505	2.51	5	63.31	2.14	5.38	7.06	2.77	4.74	5.4	2.95	4.57	17.8
39	Oryza brachyantha	93	163531	2.25	5.24	5.05	2.03	5.47	5.31	2.65	4.85	3.59	2.73	4.77	2.5
40	Oryza eichingeri	9	165993	2.78	3.16	44.95	3.13	2.81	44.42	3.27	2.67	45.4	2.79	3.16	45.51
41	Oryza longistaminata	1030	163319	3.04	4.59	4.94	2.49	5.14	5.29	3.33	4.3	3.73	3.29	4.34	3.13
42	Oryza puntata	78	170450	0.72	2.45	16.35	0.07	2.49	19.29	0.72	2.45	20.34	0.84	2.33	15.21
43	Panicum comorense	15	152496	0.72	6.31	47.29	0.95	6.09	55	2.9	4.14	53.55	2.4	4.64	47.1
44	Panicum repens	400	171196	0.52	2.19	13.05	0.45	2.18	14.1	0.65	1.97	14.9	0.07	1.9	15.45
45	Phoenix reclinata	333	171879	0.59	1.65	10.26	0.52	1.72	8.61	0.84	1.4	10.23	0.72	1.52	11.22
46	Saccharum spontaneum subsp. aegyptiacum	4	172123	0.61	1.56	18.56	1.65	0.51	12.35	1.07	1.04	27.3	1.07	1.1	27.31
47	Sorghum drummondii	5	146444	5.06	14.96	26.66	5.58	14.44	41.9	7.96	12.06	27.3	7.62	12.4	29.48
48	Sorghum purpureosericeum	3	113928	48.72	41.79	50.51	48.51	54.37	49.94	48.86	4.97	46.42	43.72	5.47	43.72
49	Vigna ambacensis	574	165812	1.33	4.71	9.06	1.05	4.98	10.57	1.7	4.33	9.63	1.05	4.98	10.57
50	Vigna filicaulis	399	115022	51.92	0.45	13.73	52.06	0.3	13.52	52.06	0.31	13.52	52.05	0.32	12.6
51	Vigna gracilis	544	170301	0.47	2.69	10.34	0.43	2.73	10.86	0.72	2.44	11.36	0.54	2.62	12.07
52	Vigna luteola	229	151744	6.18	9.32	4.37	7	8.49	4.72	3.57	11.93	2.84	4.56	10.93	5.79
53	Vigna marina	40	172786	0.24	1.42	18.74	0.23	1.43	17.66	0.26	1.4	17.23	0.22	1.44	19.49
54	Vigna multinervis	176	171484	0.77	1.74	6.77	0.71	1.8	8.9	0.77	1.74	6.77	0.67	1.84	9.68
55	Vigna nigritia	244	171373	0.34	2.24	16.68	0.33	2.26	13.38	0.33	2.26	13.38	0.73	16.69	13.48
56	Vigna oblongifolia	167	175313	0.01	0.31	20.85	0.02	0.3	20.63	0.01	0.31	20.85	0.05	0.27	19.74
57	Vigna racemosa	1352	167977	0.94	3.6	9.77	0.9	3.64	9.24	0.9	3.64	9.24	1.27	3.27	9.77
58	Vigna reticulata	578	168504	1.82	2.39	10.88	1.48	2.73	7.71	1.68	2.53	8.96	1.86	2.35	9.89
59	Vigna unguiculata subsp. baoulensis	39	148254	8.79	9.73	44.98	9.15	9.37	54.22	8.42	10.1	44.41	8.42	10.1	44.41
60	Vigna unguiculata subsp. dekindtiana	333	163247	4.38	3.28	6.81	4.02	3.64	7.88	2.82	4.84	23.75	2.64	5.02	33.44

61	Vigna unguicul subsp letouzeyi	6	172480	13.28	0.36	1.62	12.84	0.8	0.18	1.28	0.8	18.48	11.94	1.7	9.37
62	Vigna unguiculata subsp unguiculata var spontanea	49	97237	21.41	28.54	38.82	22.66	27.29	37.28	20.33	29.63	34.73	19.41	30.54	27.81
63	Vigna unguiculata subsp. stenophylla	13	159572	2.34	7.73	31.52	1.78	8.29	30.59	3.42	6.65	22.6	3.42	6.65	22.6

Table 5S4: Magnitude of range shift for the West African CWR at genepool level

s/n		SSP 245 (2050)	SSP 245 (2050)	SSP 245 (2050)	SSP 245 (2070)	SSP 245 (2070)	SSP 245 (2070)	SSP 585 (2050)	SSP 585 (2050)	SSP 585 (2050)	SSP 585 (2070)	SSP 585 (2070)	SSP 585 (2070)
		Conraction	Occupied	Expansion	Conraction	Occupied	Expansion	Conraction	Occupied	Expansion	Conraction	Occupied	Expansion
1	Kola	0.438	0.607	43.14	0.44	1.42	43.76	0.51	1.34	24.42	0.77	1.08	31.47
2	Fonio	5.39	8.42	34.93	4.9	8.91	38.29	7.26	6.55	49.37	5.5	8.31	39.1
3	Yam	6.25	41.88	131.4	8.75	23.1	125	6.95	21.93	132	7.1	22	126.47
4	Barnyard millet	2.39	11.81	43.75	1.66	12.54	49.35	3.73	10.48	37.19	3.57	10.63	42.29
5	Finger millet	2.82	10.76	20.56	2.5	11.09	22.02	7.1	6.49	11.54	4.65	8.94	19.5
6	Teff	4.2	4.47	46.4	4.03	5.99	49.04	3.33	5.35	39.34	3.21	6.81	37.01
7	Cotton	11.86	34.49	88.64	11.5	34.86	95.95	14.02	32.21	107.1	12.97	33.36	87.86
8	Sweet potato	33.348	112.437	408.82	33.78	97.91	423.41	9.45	24.1	136.9	11.71	18.8	127
9	Cassava	1.1	1.5	51	0.39	2.2	22.57	0.57	2.02	54.83	1.2	1.39	49.08
10	Rice	53.328	163.657	615.42	52.2	152.05	612.99	12.74	19.01	78.46	12.6	19.2	84.2
11	Proso millet	1.24	8.5	60.34	1.4	8.27	69.1	3.55	6.11	68.45	2.47	6.54	62.6
12	Date palm	0.59	1.65	10.26	0.52	1.72	8.61	0.84	1.4	10.23	0.72	1.52	11.22
13	Sugarcane	0.61	1.56	18.56	1.65	0.51	12.35	1.07	1.04	27.3	1.07	1.1	27.31
14	Sorghum	53.78	56.75	77.17	54.09	68.81	91.84	56.82	17.03	73.72	51.34	17.87	73.2
15	Cowpea	114.2	78.51	244.94	114.7	78.05	247.3	98.27	82.91	257.8	108.8	98.72	261

Table 6S1: Threat assessed West African CWR and habitat found

S/n	List of taxa	Habitat
1	*Digitaria barbinodis* Henrard	Savanna – moist, Shrubland – subtropical/tropical dry, Shrubland – subtropical/tropical moist.
2	*Digitaria ciliaris* (Retz.) Koeler	Forest – subtropical/tropical moist lowland, Forest – subtropical/tropical moist montane, Savanna – moist, Rocky areas (eg. Inland cliffs, mountain peaks), Desert – hot, Desert – temperate, Artificial/terrestrial – plantation.
3	*Digitaria fuscescens* (J. Presl) Henrard	Savanna – moist, Shrubland – subtropical/tropical moist, Grassland – subtropical/tropical seasonally wet/flooded.
4	*Digitaria iburua* Staf	Savanna – dry, and Savanna – moist, Shrubland – subtropical/tropical moist.
5	*Dioscorea alata* L.	Artificial/terrestrial – arable land, Artificial/terrestrial – subtropical/tropical heavily degraded former forest
6	*Dioscorea bulbifera* L.	Forest – subtropical/tropical moist lowland, Shrubland – subtropical/tropical moist, Artificial/terrestrial – arable land, Artificial/terrestrial – subtropical/tropical heavily degraded former forest.
7	*Dioscorea cayanensis* Lam.	Forest – subtropical/tropical moist lowland, Savanna – moist, Shrubland – subtropical/tropical moist.
8	*Dioscorea sagittifolia* var. *lecardii* (De Wild.) Nkounkou	Shrubland – subtropical/tropical moist, Shrubland – subtropical/tropical high altitude.
9	*Dioscorea sansibarensis* Pax	Forest – subtropical/tropical mangrove vegetation above high tide level, Artificial/terrestrial – subtropical/tropical heavily degraded former forest.
10	*Echinochloa crus – galli* (L.) P. Beauv	Savanna – moist, Wetlands (inland) - seasonal/intermittent irregular river/streams/creeks, Wetlands (inland) – bogs, marshes, swamps, ferns, peatlands, Wetlands (inland) - seasonal/intermittent freshwater marshes/pools (under 8ha), Wetlands (inland) – Permanent freshwater marshes/pools (under 8ha), Wetlands (inland) – permanent freshwater lakes (over 8ha), Artificial/aquatic – ponds (below 8ha), Artificial/aquatic – excavations (open), Artificial/aquatic – irrigated land (includes irrigation channels), Artificial/aquatic – seasonally flooded agricultural land and Artificial/aquatic – canals drainage channels, ditches.

11	*Eleusine africana* Kenn- O'Byrne	Wetlands (inland – permanent rivers/streams/creeks (includes waterfalls), Artificial/terrestrial – arable land.
12	*Eleusine indica* (L.) Gaertn.	Grassland – subtropical/tropical seasonally wet/flooded, Grassland – subtropical/tropical high altitude, Wetlands (inland) - seasonal/intermittent irregular river/streams/creeks, Wetlands (inland) – bogs, marshes, swamps, ferns, peatlands, Wetlands (inland) – permanent freshwater lakes (over 8ha), Wetlands (inland) - seasonal/intermittent freshwater marshes/pools (under 8ha), Wetlands (inland) – Permanent freshwater marshes/pools (under 8ha), Artificial/aquatic – wastewater treatment areas, Artificial/aquatic – irrigated land (includes irrigation channels), Artificial/aquatic – seasonally flooded agricultural land, and Artificial/aquatic – canals drainage channels, ditches.
13	*Eragrostis pilosa* (L.) P. Beauv.	Artificial/terrestrial – plantation , Artificial/terrestrial – urban areas.
14	*Eragrostis unioloides* (Retz.) Nees ex Steud.	Forest – subtropical/tropical dry, Savanna – dry, Savanna – moist, Shrubland – subtropical/tropical moist, Shrubland – subtropical/tropical dry, Shrubland – subtropical/tropical high altitude, Wetlands (inland) – bogs, marshes, swamps, ferns, peatlands, Wetlands (inland) - seasonal/intermittent freshwater marshes/pools (under 8ha), Wetlands (inland) – permanent freshwater lakes (over 8ha), Rocky areas (eg. Inland cliffs, mountain peaks), Desert – hot, Artificial/terrestrial – arable land, Artificial/ terrestrial – pastureland, Artificial/terrestrial – plantation, Artificial/ terrestrial – rural gardens, Artificial/terrestrial – urban areas, Artificial/terrestrial – subtropical/tropical heavily degraded former forest, Artificial/aquatic – irrigated land (includes irrigation channels), Artificial/aquatic – seasonally flooded agricultural land.
15	*Ipomoea acanthocarpa* (Choisy) Hochst. ex Schweinf. & Asch	Wetlands (inland – permanent rivers/streams/creeks (includes waterfalls), Wetlands (inland) – shrub dominate wetlands, Wetlands (inland) – bogs, marshes, swamps, ferns, peatlands, Wetlands (inland) - seasonal/intermittent freshwater marshes/pools (under 8ha)
16	*Ipomoea argentaurata* Hallier f.	Savanna – moist, Shrubland – subtropical/tropical moist
17	*Ipomoea asarifolia* (Desr.) Roem. & Schult.	Wetlands (inland) - seasonal/intermittent irregular river/streams/creeks, Artificial/aquatic – seasonally flooded agricultural land, Artificial/aquatic – canals drainage channels, ditches.

18	*Ipomoea barteri* Baker	Savanna – moist, Shrubland – subtropical/tropical dry, Shrubland – subtropical/tropical moist, Grassland – subtropical/tropical dry.
19	*Ipomoea blepharophylla* Hallier f.	Shrubland – subtropical/tropical moist, Grassland – subtropical/tropical seasonally wet/flooded, Grassland – subtropical/tropical high altitude.
20	*Ipomoea chrysochaetia* Hallier f.	Forest – subtropical/tropical moist lowland, Shrubland – subtropical/tropical moist, Grassland – subtropical/tropical high altitude, Shrubland – Mediterranean – type shrubby vegetation.
21	*Ipomoea coptica* (L.) Roth ex Roem. & Schult.	Wetlands (inland) - seasonal/intermittent irregular river/streams/creeks, Artificial/aquatic – irrigated land (includes irrigation channels), Artificial/aquatic – seasonally flooded agricultural land
22	*Ipomoea prismatosyphon* Welw.	Savanna – dry, Savanna – moist, Shrubland – subtropical/tropical high altitude.
23	*Saccharum spontaneum* subsp. *spontaneum* L.	Forest – subtropical/tropical dry, Shrubland – Mediterranean – type shrubby vegetation
24	*Saccharum spontaneum* subsp. *aegytiacum* (Willd.) Hack.	Shrubland – subtropical/tropical dry, Shrubland – Mediterranean – type shrubby vegetation