Assessment of agrobiodiversity resources in the Borotse flood plain, Zambia

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ASSESSMENT OF AGROBIODIVERSITY RESOURCES IN THE BOROTSE FLOOD PLAIN, ZAMBIA

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EXECUTIVE SUMMARY

Concerns about perceived loss of indigenous materials emerged from multiple stakeholders during consultations to plan and design the CGIAR Research Program on Aquatic Agricultural Systems for the Borotse hub in Zambia's Western Province. To come to grips with and address the concerns, the AAS Borotse hub program of work included an assessment of agrobiodiversity to inform community-level and program initiatives and actions. The agrobiodiversity assessment comprised three components: key informant and expert surveys complemented by review of grey and published literature, focus group discussions in the communities, and individual household surveys. This working paper reports the findings from assessments of agrobiodiversity resources in the Borotse hub by key informants and local experts working in government ministries, departments and agencies, and non-governmental organizations operating in the communities. This working paper covers the following topics: agriculture in the Borotse flood plain; major agricultural land types in the Borotse flood plain; soils and their uses; production systems; crops, including the seed sector and ex-situ resources; indigenous materials collected from the wild, including non-perennial and perennial plants, aquatic plants, and forest biodiversity; fish resources, including both capture fisheries and aquaculture; livestock resources; dietary diversity; and indigenous and local knowledge on management systems.

Insights from the agrobiodiversity assessments include exploring the following: options for improving livelihoods of households through more systematic cultivation of edible mushrooms, woody perennials and new crops linked to market opportunities; community-led initiatives to promote sustainable access to and use of forest biodiversity and ecosystem services associated with woodlands; a sustainable mechanism for predicting and informing residents of the flood plain about the likely commencement and retreat of floods; and adapting farming practices to the vagaries of the floods through participatory investigation and design of feasible options for farmers to use different land types available to farmers in the Borotse flood plain. We noted that low yields of the major cultivated crops (rice, maize, sorghum, millet, cassava, etc.) point to opportunities for productivity improvements involving early-maturing varieties, as well as matching varieties to flooding regimes for the different land types and rains, timely availability and access to high-performing seeds, soil amendments to enhance nutrient availability, and cultural practices to control weeds in the fragile wetland ecosystem and optimize planting.

Gender differentiation in access to resources and participation in economic opportunities, where they occur, have been highlighted in the paper. The AAS gender thematic area may want to explore, with the help of local women's groups and traditional authorities, how best to overcome discriminatory practices against women and enhance mutually beneficial roles between genders. For the follow-up focus group discussions on agrobiodiversity assessment in the 10 communities identified by the AAS program for research-in-development initiatives, we identified the need to use problem tree methodology (to explore why many households do not produce enough food to sustain them over a year, as well as options for remedying the situation) and four cells methodology (to identify major crops and varieties and minor crops and varieties that risk disappearance). Finally, in view of the importance of fish, livestock and crops in the Borotse flood plain, the AAS productivity thematic area may want to explore options for beneficial integration and test these options for their suitability and acceptance by farmers in the Borotse study villages.

INTRODUCTION

The Borotse flood plain (Figure 1) comprises extensive grasslands from Lukulu, near the Zambezi River's confluence with the Kabompo and Lungwebungu rivers, to Senanga district in the Western Province of Zambia. It includes a system of arable land, canals, lagoons and swamps. Its area is broadly estimated at 550,000 hectares, with a total wetland area of 1.2 million hectares (Turpie et al., 1999). The flood plain gets flooded after the main rainy season, with floods peaking in April and receding by July. The annual flooding regime in the Borotse flood plain has an important influence on the livelihoods and economies of households that practice agriculture on the plains, particularly as it forces seasonal migration of people and livestock to higher ground during flooding.

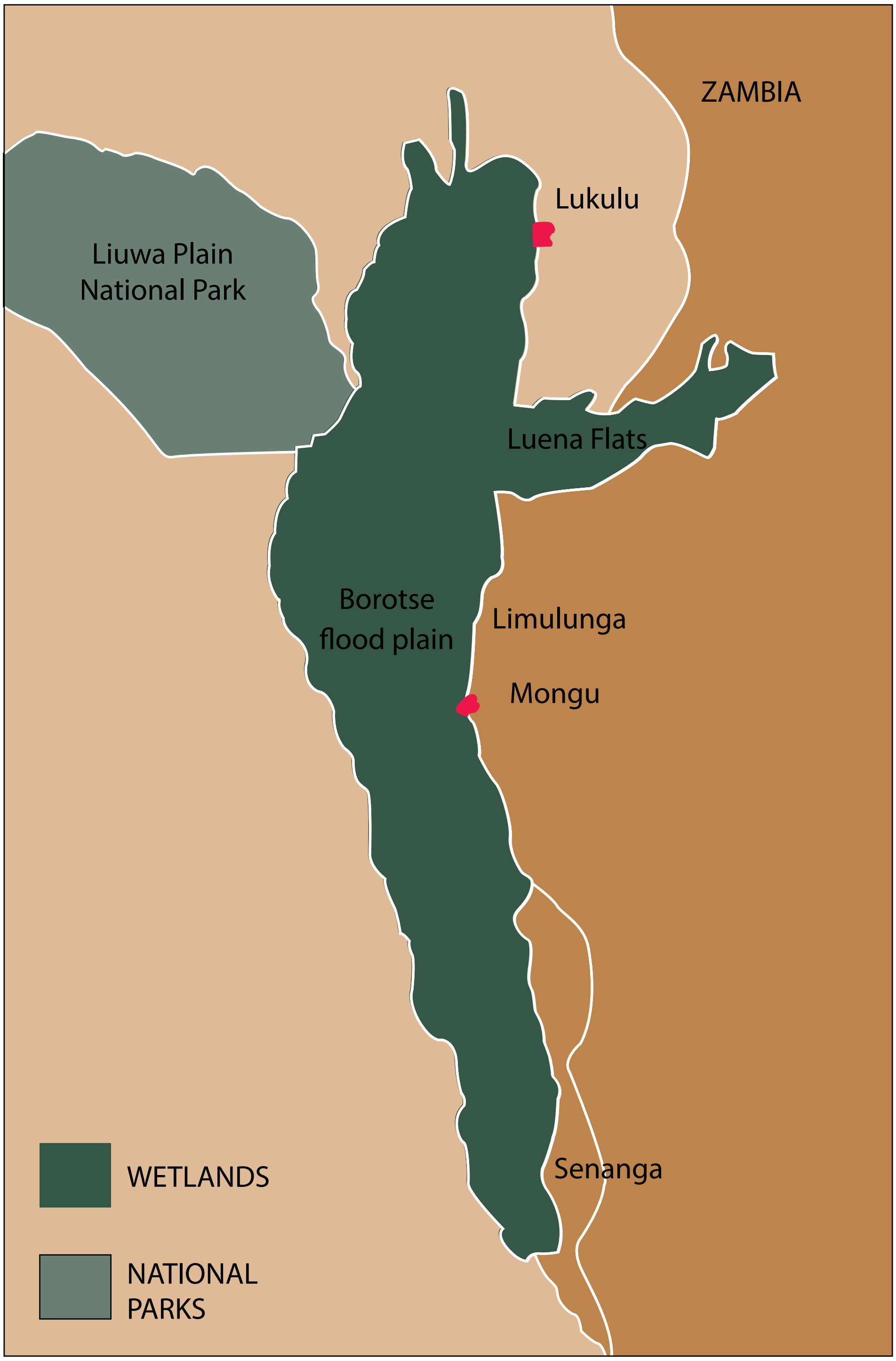

Figure 1. Map of Borotse flood plain

AGRICULTURE IN THE BOROTSE FLOOD PLAIN

Agriculture is the mainstay of most people in the Borotse flood plain, especially in rural communities. Turpie et al. (1999) report that about 90 percent of the population is involved in agriculture, mostly for subsistence. According to Simwinji (1997), the total agricultural land in Western Province is estimated at 279,000 hectares. Mongu East and the Borotse plains are the main agricultural production areas. The agricultural economy of the Borotse flood plain involves a strong interaction between herding, cropping and fishing activities (Simwinji, 1997). Agricultural inputs for small-scale farmers consist predominantly of hand hoes, animal draft power and hired labor for farm operations. Inorganic fertilizers are accessed, where possible, through Farmer Input Support Program (FISP). There are very few established agro-input dealers. Soil type, topography, hydrology (frequency of flooding), a high water table in the Zambezi flood plain, and the "dambos"[1] on the upland, as well as pest and livestock damage, are the main factors influencing the farming system practiced. Rain-fed crop production occurs mostly in selected flood plain and upland areas. Poorly developed infrastructure (roads, dams and canals) and markets, as well as inadequate inputs, constitute major constraints to agriculture. Road rehabilitation, canal clearing to facilitate irrigation and drainage, and ease of access to farm inputs (seed, fertilizer, implements, etc.) are key factors for improving agriculture, particularly for the smallholders. During the lean months of October or November to January, stored produce from the previous growing season typically gets exhausted and new food crops are not available; as a result, food and nutrition insecurity occur in households. This food insecurity is particularly critical during periods when fishing is banned to allow for spawning and floods may have forced migration of people and livestock to upland areas. It is in this prevailing context of opportunities and constraints offered and posed by the natural resources and seasonal flooding of the Borotse flood plain that the CGIAR's AAS program set up a hub in Zambia's Western Province to engage in research-in-development activities in partnership with multiple stakeholders.

The development challenge set by the CGIAR, along with the multiple development partners in the AAS hub, is "to make effective use of the seasonal flooding and natural resources in the Borotse flood plain system through more productive and diversified aquatic agricultural management practices and technologies that improve the lives and livelihoods of the poor." The AAS research-in-development initiatives in the Borotse flood plain involve a participatory approach that explores and harnesses indigenous knowledge, local biodiversity resources, partnerships with development actors (NGOs, government and private sectors) and efforts of local communities. Such knowledge, resources and partnerships will be deployed to develop the potential of the flood plains and adjacent upland areas to improve productivity and livelihoods (income, food and nutrition) while minimizing risks to people living in the Borotse flood plain.

Stakeholder consultations were organized to inform the planning for the AAS hub program of work. A key concern expressed during these consultations was the need to understand the status of the natural resources in the Borotse flood plain, so as to address any loss or disappearance of indigenous materials. As a first step toward addressing the stakeholder concerns on food resources and gathering information to inform hub-level or community-led initiatives, the AAS hub program of work for the Borotse flood plain included an assessment of agrobiodiversity resources. The baseline assessment of biodiversity resources in the Borotse flood plain was structured to cover three aspects: a literature review complemented by information from experts or key informants, focus group discussions in 10 villages selected by the AAS hub program for initial research-in-development activities, and individual household surveys. This report synthesizes primary and secondary information and data on biodiversity resources gathered from experts who currently work or have worked in the Borotse flood plain in Zambia's Western Province. Agrobiodiversity resources reviewed include both cultivated species and plant species collected by households from the wild for domestic use. The objective of this initial phase of the agrobiodiversity assessment is to provide a consolidated synthesis of existing knowledge, identify key issues for further exploration, and inform participatory action research with communities by partners in the CGIAR-led AAS research in development in Zambia's Western Province.

Annex 4 contains a schematic presentation of the demand and supply conceptual framework that guided the development of the questionnaire[2] used to collect primary data and information from experts and key informants. The demand factors covered food-security-related agricultural and forest biodiversity resources important for household diets, livestock feed and meeting other household needs (e.g., income and construction). The supply factors covered plants cultivated or collected from the wild, livestock, edible insects, and exchanges in formal markets and informal settings. Gender role, cultural, economic, communal land governance, policy, institutional and environmental dimensions of the demand and supply factors were integrated into the survey questionnaire. We also sought information on diversity of domesticated and wild plant and animal species (including those found in various types of gardens), management and uses of resources, formal and informal seed systems for key crops grown, conservation strategies, challenges and drivers of identified challenges, potential local remedies, and possible external remedies to consider. The key informants consulted were representatives of government departments in the Ministry of Agriculture and Livestock (Fisheries, Nutrition, Forestry, Farmer Input Support Program, Plant Genetic Resources Unit of Zambia Agricultural Research Institute at Mount Makulu) and non governmental agencies and institutions (Caritas, Concern International, CeLIM and University of Borotseland). Other types of information (including data) were gathered from reports of the National Seed Certification Unit of the Seed Control and Certification Institute, as well as from the grey literature.

The rest of this working paper covers the following areas for the Borotse flood plain, numbered by section: (iii) major agricultural land types; (iv) soils and their uses; (v) production systems; (vi) crops (including the seed sector); (vii) indigenous resources collected from the wild; (viii) fish resources; (ix) livestock resources; (x) dietary diversity; (xi) indigenous knowledge and management systems; (xii) environmental issues; and (xiii) a summary synthesis and recommendations.

MAJOR AGRICULTURAL LAND TYPES IN THE BOROTSE FLOOD PLAIN

Cassava field near Mapungu village, Kalabo district

The major agricultural land types in the Borotse flood plain are identified and classified on the basis of the topography and flooding characteristics of the landforms.

- "Milapo" (plural of "mulapo") represent landforms along waterways. These landforms are lower than the general level of the flood plain or are bound by "matongo."
- "Matongo" (plural of "litongo") are rarely flooded landforms often found at the margins of the Borotse flood plain.
- "Mazulu" (plural of "lizulu") consist of landforms raised above the general flood plain level. They have some of the best soils in the flood plain but are also exposed to risks from flooding and drought, and some are left fallow due to their inaccessibility.
- "Sitapa" represent landforms on which annual flooding of the flood plain deposits silt and humus from vegetation and decaying aquatic plants. These deposits enrich the fertility of the land on the plains, creating fertile arable land for crop production. However, in the late-season heat after the floods have receded, the soils harden.

SOILS AND THEIR USES

Soils in Zambia consist of four categories:

- Red sandveld soils, which are generally not fertile except where the topsoil has higher clay content.
- Grey "dambo" soils, which generally contain more nutrients but get waterlogged during rainy seasons and are often acid, hence limiting the types of plants that can be grown to those that grow on marshy lands.
- Black soils in flood plains, which are fertile and on which grasses grow as soon as annual floods recede.
- Kalahari sands, which tend to be inherently infertile with poor moisture retention capacities.

The soil type map for Zambia, compiled by the Soil Survey Unit of Mount Makulu Central Research Station, shows that the predominant soil types almost everywhere in Western Province are arenosols, with seasonally waterlogged gleysols and associations along the river courses. The arenosols, along with podozols, which are confined mainly to Western and North-Western provinces, are very infertile and have sandy textures with little or no profile development associated with the Kalahari sand deposits, which have a soil pH less than 4.0 and strong acid reaction. Since the nutrient level is very low, lands on which these soils occur have very low agricultural potential and are typically only marginally suitable for cassava. However, with regular liming and fertilizer application, the soils may support maize, sorghum, beans, groundnuts, cassava and millet (JAICAF, 2008).

Locally, the soils in the Borotse flood plain cover the following: Kalahari sands (principally "mushitu" and "matongo" soils on flood plain edges, which experience a high dynamic water table); "shishanjo" soils, found on the flood plain; pan, drained; and "dambo" soils. The different soils found in the Borotse flood plain are planted to different crops in predominant production systems. Without manure application to maintain soil fertility or intercropping with leguminous crops, nutrient stocks in "mushitu" soils are exhausted after 2–3 years of cultivation. However, the ease of access to forest lands for new cultivation represents a likely disincentive to investment in land fertility maintenance on these soils.

Photo Credit : Sondo Chanamwe/Natural Resources Development College, Lusaka, Zambia

Soil on which cassava is grown near Mapungu village, Kalabo district

PRODUCTION SYSTEMS

Three main farming system classifications exist in Zambia's Western Province: (1) crop-based commercial agriculture centered on Kaoma; (2) wetland agricultural systems covering four districts in the Borotse flood plain (Kalabo, Lukulu, Mongu and Senanga); and (3) traditional subsistence agricultural systems on the plateau, centered on Sesheke. Production systems in the Borotse flood plain are dominated by crop-livestock (mainly cattle) mixtures, on lowlands or upland areas, and irrespective of farm size. Crop-livestock interactions are the norm. The communal cattle-grazing practices provide access to crop residues on farmlands by grazing cattle in exchange for manure dropped while grazing. However, farmers who do not own cattle are likely to lose valuable crop residues, which could have been returned as organic material to the soil, with receipt of little or no manure in return. In addition to communal grazing, cattle-owning farmers practice a system of shifting the cattle kraal every week to facilitate the accumulation of manure on entire fields ("kutulisa"). Apart from the residue and manure exchange, cattle provide milk for family consumption. Possession of cattle also gives better access to draft power for tilling land.

Simwinji (1999) and IUCN (2003) present eight categories of cultivated fields in the Borotse flood plain:

- "Matema" — dryland field. These are upland fields under shifting cultivation within woodlands.

- "Lizulu" — raised garden within the flood plain. These are cultivated to rain-fed crops (mainly maize, sorghum and millet), and cover about 0.5 percent of the total flood plain area.

- "Mazulu" — consist of some of the best soils but also carry risks of flooding and drought. Their inaccessibility results in many of these fields being left fallow. "Mazulu" are planted to different crops, especially maize, during the rainy season (starting in November) but could be cropped earlier with irrigation.

- "Litongo" — village garden. These are found on the upper slopes of the plain margin. Village gardens are cultivated to mixed rain-fed crops (including vegetables and fruit trees) during the rainy season. Although the soils found on the "litongo" are not naturally fertile, cattle manure is sometimes applied.

- Wet "litongo" — seepage garden. These are used intensively for cultivation of mixed crops.

- "Shishango" — drained seepage garden. These are found in permanently waterlogged areas in which crop cultivation is risky due to flooding. The soils are poorly drained and difficult to till. The farming practices on the "shishango" soils involve the digging of trenches around garden beds to drain mounds. The fertility of its acidic peats can be increased by burning them to raise the pH and nutrient availability. During the dry season, "shishano" soils found on the flood plain and "dambo" soils are irrigated and cultivated to maize (Zea maïs), sorghum (Sorghum bicolor), tomatoes (Solanum lycopersicum), onions (Allium cepa), rape (Brassica napus L.) or mustard (Brassica juncea), cabbage (Brassica oleracea capitata), sweet potatoes (Ipomoea batatas), and pumpkins (Cucurbita spp.). Poor weeding practices and soil nutrient maintenance, as well as high pest and disease incidence, contribute to poor yields. Increased use of compost and integrated pest management techniques could facilitate continuous farming of vegetables. Continuous cropping of maize and sorghum could require the application of manure, compost or green tree leaves to the field and the rotation of the cereals with groundnuts, beans or a combination of the two.

- "Sitapa" — lagoon garden. These are found on naturally fertile inner margins of the flood plain. "Sitapa" is often planted to maize to make use of available soil moisture in July and August, but the growing season for maize is short due to high risk of flooding. At the same time, however, the flooding provides opportunities for rice cultivation.

- "Litunda" — small riverbank garden. This type of garden is planted to maize and root crops.

The general cropping calendar in Borotse flood plain involves land preparation any time between October and January, a rain-fed growing season from November to late March or early April, and harvesting between March and May. Cereal and legume grain yields are very much dependent on water availability, especially during floret or flower initiation.

A rice-vegetable rotation system is practiced on the "milapo" land type, which is ploughed using oxen, and then planted to rice (Oryza spp.) from early November to early January. With fertilizer applied, rice yields are estimated at about 2 tons per hectare. Weeds represent a major constraint, demanding weed control techniques that would not negatively impact the fragile wetland environment.

"Matongo" and "mazulu" land types are ploughed with oxen or tilled with hand hoes, and then planted to maize, mainly for subsistence. On "matongo" soils (Kalahari sands on flood plain edges), which experience a high dynamic water table, cereals are planted in October with the first rains, when the water table is high. Maize yields are typically low, about 1–2 tons per hectare. In the absence of the application of mineral fertilizer or manure, soil nutrients are exhausted after 2–3 years of cropping the same field. Soil nutrient deficits are principally due to limited availability of manure and lack of soil amendments (sometimes due to exclusion of some households from participating in cooperatives because they cannot afford to pay required membership fees). Poor fertility and the low organic matter content of these sandy soils represent important constraints to continuous productive farming. Fertility of these fields could be maintained through fertilizer application and increased retention of organic materials from green tree leaves, compost, crop residue and manure. Most mineral fertilizer inputs are poorly suited to sandy soil conditions and flooding, which result in excessive leaching and nutrient volatilization, particularly of nitrogen.

According to the local experts and key informants, improvements to existing crop production systems and livelihoods of people who depend on cropping the Borotse flood plain could come from planting maize varieties that are planted before the rains in the "sitapa" fields, maize varieties that keep cobs high above the floodwater line, and sorghum varieties that tolerate flooding for months, just like rice.

Residents of upland areas generally have access to "matema" and "matongo," but have less access to other field types. Arable land is limited along the fertile plain edges. Literature shows that the average area cultivated in the Borotse flood plain is about 2.9 "lima," which is roughly 0.74 hectares. Based on findings from earlier studies, field size was found to be significantly positively correlated with household size ($n = 136$, $P < 0.05$) and wealth with richer households cultivating larger fields than the average (Turpie et al., 1999).

Crops and varieties

The major rainy season crops include rice (Oryza spp.), grown on lower areas ("litapa"); maize (Zea maïs), grown on raised mounds ("mazulu"), and cassava (Manihot esculenta), grown on the upland areas. Maize is the preferred crop on lowlands after the rains or on "mazulu" landforms during the rainy season. Maize is planted on fields in the plain and on good upland soils, while poorer fields are generally cropped with sorghum, millet and cassava.

Varieties of pearl millet (Pennisetum glaucum), cassava and paddy rice are mostly indigenous (locally recycled planting materials). Cucurbits (mostly Cucurbita and Citrullus) and cowpeas (Vigna unguiculata) are other notable crops for food security. The influence of government policy implemented through farmer support programs facilitates farmer access to subsidized mineral fertilizer and maize seed. These support programs have transformed maize into an important household crop for most smallholder farmers in Western Province over a number of years. Farmers practice both rain-fed and winter cropping in the aquatic systems. Winter cropping is locally known as "madimba."

In order for maize to benefit from the seasonal flooding experienced in the Borotse flood plain, flooding of the low-lying "sitapa" must come late and dry early to permit planting in September. Also, the flooding must not reach the "mazulu" land types before maize matures. When flooding of the "sitapa" occurs early and dries up late then different maize varieties with a shortened cycle, or a different crop entirely, may need to be considered for the "sitapa."

Maize varieties cultivated in the Borotse flood plain include some purchased hybrids (usually 400 series). Cases of recycling of seeds purchased from the market occur. There are also maize landraces such as colored flints ("munali"), dents (Hickory King or "gaankata") and some recycled yellow maize ("buusumili"), first introduced to the Borotse flood plain in the early 1990s when devastating droughts were experienced. Only 10 percent of maize fields are planted to landraces — mainly Hickory King with some flint.

Rice is an important cash crop, cultivated on sandy flood gardens (Simwinji, 1997) in the Borotse flood plain. Some of the rice varieties cultivated in the Borotse flood plain include "mongu supa" (mainly cultivated for sale), Angola, Yangshzu (pronounced "yan-zoo"), blue bonnet, "zawa" and "kajakete" (the local rice variety that has a double seed coat, making it difficult for birds to pick grains, Gershon et al., 2012). Rice is cultivated on "litapa" (flood plains) or on "mazulu" (raised areas in the flood plains). Floods are needed for rice cultivation on "milapo" to ensure undisturbed grain filling. The most popular rice variety, "mongu supa," is photoperiodic, and if water drains quickly from the field grain filling is hampered. In areas where "milapo" have water even during harvest time, no water stress is experienced during crop growth. Rice farming practices involve puddle paddies and broadcasting; transplanting is rare. Rice yields are about 1–2 tons per hectare and are entirely dependent on flood levels. Weeds pose a major problem. The burning of rice residues, lack of external inputs and lack of extension education are pertinent issues to explore in order to facilitate continuous rice cropping on these landforms. Increased intensification, preservation of organic matter from paddies during the off-season, and short-term fallows are recommended.

Cassava (Manihot esculenta), pearl millet (Pennisetum glaucum), and sorghum and other minor crops are cultivated as rain-fed crops on deep Kalahari sands ("mushitu"). Cassava is planted in October (before the rains), at random spacing. Cassava yields are low, estimated at 2–3 tons per hectare. Key informants suggested that the sandy soils would benefit from improvement in organic matter content from the return of organic materials to the soil through compost, manure, or rotation of cassava with beans or groundnut. The broadcasting of black sunnhemp (Crotalaria spp.) or velvet beans (Mucuna pruriens) at the time of planting cassava cuttings presents an option for facilitating continuous farming of "mushitu" soils. Bananas (Musa spp.) are also planted on some fields.

Some crop varieties cultivated in the Borotse flood plain include the following:

- Sorghum — "sipopa" (white), multiple other landraces.
- Millet — "lubasi," "kaufela" and "dola."
- Cassava (Manihot esculenta) — "kapumba," "nalumino" and "nakamoya."
- Vegetables — Chinese cabbage, tomato, onions, roselle ("sindambi") and amaranthus ("libowa"), as well as blackjack collected from the wild.
- Groundnuts (Arachis hypogea) — Natal common, MGV4 or "makulu," and "chishango."
- Bambara groundnut (Voandzeia subterranea (L.) thouars) — local white.
- Cowpeas (Vigna unguiculata) — traditional climbing varieties and "lutembwe."
- Sweet potatoes (Ipomoea batatas) — multiple varieties.

The gaps between potential research yields for most crops at station level and average yields obtained at farm level remain wide due to differences in crop husbandry and agronomic practices between the station trials and the farms. There are opportunities for the AAS productivity thematic area to explore opportunities, through agronomic studies, to narrow existing yield gaps.

Where farmers are experiencing the impact of climate change on particular crop yields, they have responded by shifting from maize to rice with flooding. However, severe and regular floods are likely to wipe out other crops such as pumpkins (Cucurbita spp.).

Seed sector

A vibrant seed industry exists in Zambia, serviced by both private and public sectors. The formal seed industry in Zambia involves the participation of both sectors, with the public sector involved in technology development and acting as sole custodian of the regulatory functions in the seed industry, and the private sector active in technology development and dissemination (Ministry of Agriculture and Livestock, 2012). Despite the well-developed formal sector, access to improved seeds by small-scale farmers is rather low. About 85 percent of Zambia's seed demand is met through the informal sector, where exchanges of poor-quality seeds that are genetically inferior occur and give very poor returns (Zambia Seed Sector Inspection Manual, n.d.). The formal seed sector actors comprise private seed companies and public research and extension services (involved in seed certification, release, production and distribution). The informal sector is dominated by a system of farm-saved seed that has been practiced for generations. Private sector seed companies operating in Zambia include Zamseed, MRI Agro, Seed Co, Pannar Seed Limited, Pioneer, Dupont, Kamano and Monsanto. In the formal sector, seed processing is mostly done with machines. The informal sector largely processes seeds by hand, although smallholders are improving seed handling. Seed storage and distribution and seed bags are increasingly being used by both the formal and informal sectors (Zambia Seed Sector Inspection Manual, n.d.).

Farmers in the Borotse flood plain do keep and grow landraces, sometimes on gardens or plots near the house, which allows them to benefit from kitchen wastes dumped there. The landraces are grown for household consumption by both smallholders and farmers who plant larger areas, but the poor tend to see the landraces as "safe bets." Generally, landraces are kept by farmers because of desirable traits that are absent in new varieties or hybrids. In maize, for example, the landrace is kept for the taste of its roasted corn on the cob and higher flour yield per unit weight. Most landraces kept by households are those of maize, rice, sorghum and crops traditionally grown by women, such as cowpeas, groundnuts (Arachis hypogaea), bambara nuts (Voandzeia subterranea (L.) thouars) and sweet potatoes (Ipomoea batatas). Also, farmers tend to save seeds of those crops whose seeds are not being sold aggressively by seed companies. Notwithstanding farmer desire to keep landraces, there is an increasing shift to new varieties and hybrids, especially by farmers who cultivate larger land areas. Also, farmers are being encouraged to shift to high-yielding varieties. New varieties and hybrid seeds of maize are purchased from stores. Crops for which farmers do not typically rely on saved seeds from the household or from the community include maize, exotic vegetables and new varieties of rice. Because of the need to ensure that crops escape floods, NGOs are encouraging farmers to increasingly use short-cycle or early-maturing varieties, which are normally also short in stature. However, the short height renders the maize plant vulnerable to destruction if the cob goes under water. The taller local cultivars have the advantage of being tall enough to keep the cob above water. In the case of rice, farmers select and keep their rice seed stocks or procure seeds from neighbors. Since rice seeds may be mixed at the time of planting, careful selection of seeds for the next cropping season is required at harvest. The key factors that influence rice varietal choice by farmers in the Borotse flood plain include consumption needs, market outlet, market price, the nature of the floodwaters and suitability for preparation of "buhobe" (local staple preparation).

Seed maize is generally harvested between May and July, and therefore seeds may not be readily available to farmers in the Borotse flood plain for September planting. This suggests the need for early-maturing varieties or earlier availability of seed maize targeted for sale to farmers in the Borotse flood plain, on lands that are not flooded or even under irrigation to ensure that agro-dealers have seeds for sale to farmers before September. Key informants noted that there were no strong gender differences with respect to accessing seeds, although women stood a better chance of securing seeds from neighbors since women are generally the keepers of seeds.

According to the input marketing officer at the Provincial Ministry of Agriculture and NGOs working with farmers in the communities, seed acquisition constraints experienced by farmers in the Borotse flood plain system include the following:

- There is a lack of agro-input businesses or agro-dealers due to the clustering of input dealers in towns, which are not readily accessible to poor farmers.
- Hybrid maize is often not suited for sandy conditions on flood plains.

Lack of both awareness and cash for purchasing seeds are constraints to accessing commercial seed or planting materials. Women in male-headed households do not control decisions on what types of seeds are purchased by the household. Prioritization in the allocation of funds is mainly for the purchase of seeds for major household cash crops and away from crops cultivated by women. Lack of training facilities constrains the capacity of extension services to impart knowledge systematically to the youth on farms. Farmers in the Borotse flood plain also complain about difficulties in timely access to improved or pure seed. Two specific constraints contributing to the difficulties are the following: 1) delays in official commencement of national seed distribution through the government-subsidized Farm Input Support Program, which does not fit the seed planting requirements or calendar in the flood plain and hence results in poor timing of the availability of subsidized seed; and 2) the cost and logistical challenges associated with purchasing commercial seed from private seed distributors. The latter is influenced by farmers' inability to save enough or mobilize funds for purchasing seeds from agents of private seed companies, as well as specific logistical challenges associated with distributing seeds to smallholders in scattered villages across a flood plain noted for its poor transport infrastructure and highly sandy soils. Remedies to these challenges may include finding innovative local saving schemes, like those operated by Caritas in some villages, to facilitate access to funds for purchasing hybrid seeds from agents of private seed companies. In the case of open-pollinated varieties, a possible avenue for dealing with the financial and logistical challenges in accessing seeds could include examining the feasibility of trained rural seed growers who would go into local seed production. In recognition of the need to improve the productivity of smallholder farmers, various stakeholders (government agencies partnering with donor agencies and NGOs) have initiated the production of improved seeds in rural areas to increase availability of genetically superior varieties and contribute to improved yields (Zambia Seed Sector Inspection Manual, n.d.). The Seed Control and Certification Institute coordinates all rural seed initiatives in Zambia aimed at developing a sustainable rural seed provision system.

Ex-situ genetic resources

Seeds of some crop varieties found in Western Province are held in collections at the National Plant Genetic Resources Center of the Zambia Agriculture Research Institute station at Mount Makulu near Lusaka. Table 1 lists crops and number of accessions of each crop held in the collections.

Flood plains in Zambia that are similar to the Borotse flood plain found in Western Province are the Zambezi flood plains of Sinazongwe and Chiawa in Southern Province. Collections of crops grown in the Sinazongwe and Chiawa areas (landraces of maize, pearl millet, sorghum, cowpea, cucurbits and sweet potatoes) could also be suitable for crowdsource testing of their suitability in the Borotse flood plain.

District of origin of collections	Collected species	Number of accessions held in collection
Lukulu	Arachis hypogeae	10
	Hibiscus spp	1
	Sorghum bicolor	7
	Vigna subterrenea	2
	Vigna unguiculata	11
	Zea mays	4
	Pennisetum indicum	1
	Solanum spp	3
Kaoma	Vigna subterrenea	6
	Vigna unguiculata	9
	Sorghum bicolor	1
	Sesemum indicum	1
	Oryza longistaminata	1
Mongu	Oryza longistaminata	18
	Vigna subterrenea	5
	Vigna unguiculata	9
	Sesbania sesban	1
Senanga	Oryza longistaminata	2
	Vigna subterrenea	1
	Vigna unguiculata	3
Sesheke	Arachis hypogeae	7
	Cleome gynandra	1
	Cucumis spp	1
	Cucurbita spp	13
	Eleusine indicum	1
	Hibiscus sabdariffa	3
	Sorghum bicolor	11
	Vigna subterrenea	8
	Vigna unguiculata	15
Shang'ombo	Vigna subterrenea	3
	Vigna unguiculata	3
	Abelmoschus esculentus	1
	Amaranths spp.	3
	Citrullus lunatus	4
	Cleome gynandra	1
	Cucurbita spp.	8
	Hibiscus spp.	2
	Sesamum indicum	1
	Sorghum bicolor	13
*Characterization of the collections is yet to be undertaken.		

Table 1. Crop collections* and number of accessions from districts in Western Province held in the genebank of the National Plant Genetic Resources Center at Mount Makulu, Lusaka, Zambia

The collections from Western Province and other regions in Zambia with growth characteristics similar to those found in the Borotse flood plain offer opportunities for restoration of desired "lost" materials. Mechanisms for the restoration of germplasm have been implemented in Rufunsa, Chikankata and Situmbeko (Mumbwa district). The germplasm restoration program for selected crop varieties is a continuation of on-farm activities initiated in these areas in 1998 by the National Plant Genetic Resources Center as part of a Southern African Development Community regional pilot study involving Malawi, Zambia and Zimbabwe.

The key elements of the germplasm restoration program, summarized in Box 1, have useful lessons for future species restoration activities in the Borotse flood plain communities.

Box 1. Species restoration experiences in Rufunsa (near Lusaka), Chikankata (Southern Province) and Situmbeko (Mumbwa district of Central Province).

In the first year of program implementation, restoration activities were started in two communities in Rufunsa, Lusaka Province. The activities were scaled up to include Chikankata in Southern Province and Situmbeko in Mumbwa district of Central Province.
Farmer group discussions highlighted building up the local seed system of traditional crop varieties as a major priority area.

Farmers attributed the vulnerability or collapse of the local seed system to the displacement of local varieties by new varieties promoted through the government-subsidized Farmer Input Support Program.

Through farmer group discussions in selected communities and exhaustive consultations among the farmers themselves, two local crop varieties of maize and groundnuts ("gankata" and "kadononga," respectively) were selected for restoration to the farming system. A start-up group of farmers within each community volunteered to spearhead the seed multiplication program, with agreement to pass on a portion of the harvested seeds to a committee for distribution to other farmers within the community during the following season. The participating farmers received training on practices to follow in growing the seed crop. Seed packs based on germplasm from the genebank and from farmers who possessed seeds of these varieties in their communities were distributed to the start-up group of farmers in the first growing season. Field days were organized on selected farmers' fields in which the lead farmers themselves were the resource persons. During the field days, other would-be seed growers signed up and learned from the lead farmers. A committee was formed from among the farmers to monitor and ensure that farmers participating in seed multiplication were implementing the program appropriately. Over the years, as a result of the multiplier effect from the seed multiplication approach adopted, the target varieties will be completely restored as part of the farming systems of households in the communities involved and beyond.

Indigenous non-perennial plant species

Annex 1 presents the Lozi, English and botanical names of the biodiverse species found in the Borotse flood plain. According to key informants interviewed, indigenous non-perennial plant species desired by residents of the Borotse flood plain, such as local vegetables and wild fruit trees, include "mampana," "linjefu" and "mashela." Priority indigenous species that are disappearing or rarely found in recent years in the Borotse flood plain include "malumba" and a flood-tolerant sorghum variety called "munanana," as well as some varieties of finger millet (Eleusine coracana Gaertn) and sweet potatoes. Changes in taste and availability of substitutes are some of the underlying or driving factors for the perceived species and varietal losses.

Perennial plant or tree species on farmlands

Trees are largely absent from the seasonally flooded areas of the Borotse flood plain (Turpie et al., 1999) except in occasional raised wooded areas of 1–2 hectares, mostly anthropogenic, which occur throughout the flood plain (Timberlake, 1997). Trees found on farmlands, garden plots and homesteads in the Borotse flood plain include mango (Mangifera indica), papaya (Carica papaya L.), china berry (Melia azedarach), pawpaw (Asimina triloba), guava (Psidium guajava), lemon (Citrus limon (L.) Burm.f.) and guava — all planted by households — and naturally growing trees such as "mazauli" (Guibourtia coleosperma), "musekese" (Piliostigma thonningii), "isunde" (Baphia massaiensis) and "mungongo" (Ricinodendron rautanenii), which is relied upon for making oil. In addition, naturally growing plants on-farm include "manganda" (Hyphaene ventricosa), "mumonsomonso" or "mimbole" (Vangueriopsis lanciflora), and "mubula" (Parinari curatellifolia) in "mushitu" fields. Trees on farms belong to the farm owners. Visitors may pick a fruit to eat but not harvest.

Forest cleared for agriculture and charcoal production

Silutoko mushroom, Senanga district

Aquatic plants

Reeds and sedges are important to rural life on the flood plain. For example, Phragmites sp. ("mataka") is used for construction, fencing courtyards, and making mats and some types of fishing apparatus (fish baskets, fish spear handles and fishing rods). Turpie et al. (1999) found from household surveys that 84 percent of households harvested reeds. Only men harvest reeds after floodwaters recede, with richer households harvesting more reeds than poorer households.

Forest biodiversity

Forest resources in the Borotse flood plain provide commercially valued timber from "mukusi" or Zambian teak (Baikiaea plurijuga), "mwande" (Afzelia quanzensis), "muzauli" or African rosewood (Guibourtia coleosperma), "mulombe" or "mukuwa" (Copaifera baumiana), and "mutuya" (Brachystegia spiciformis). See Annex 1 for more botanical names. However, forest resources are under increasing pressure from logging for poles, fiber, ropes, charcoal and artisanal crafts, as well as from bush fires and total vegetation clearance for farmland preparation. Valuable tree species such as "muzauli," "mwande," "mukusi," and "mukwa" or "mukuwa" (Copaifera baumiana) have been depleted. The predominant forest resources (usually Julbernardia sp.) are cleared and burned to produce charcoal for sale. Charcoal is not only used by households to meet cooking energy needs but is also sold to provide a source of income. Curios are manufactured from trees like "mungongo," "mukelete" or African blackwood (Dalbergia melanoxylon), "munganyama" or purple-leaved albizia (Albizia antunesiana), and "munjonjolo" (Diospyros batocana), and "makenge" or "mukenge" (Combretum zeyheri) is used for basketry.

Women typically access virgin land (despite ownership) because of their inability to clear the land for cultivation (mainly because women do not have the resources to cut trees and lack access to oxen or draft power for plowing new fields).

Forests are also sources of naturally growing mushrooms, possibly associated with termite activities, etc., and are collected for household consumption and sale.

Capture fishery in the Borotse flood plain

The Zambezi River and its tributaries provide habitat for freshwater fish resources ranging from socially and economically significant species such as tigerfish (Hydrocynus vittatus) and lungfish (Protopterus annectens brieni) to rare or endemic cichlid (tilapias) and cyprinid species (Mandima and Mwima, 2005). The vast flood plains and swamps of the Upper Zambezi are breeding and feeding grounds for a moderately rich fish fauna, including a near-endemic radiation of large riverine cichlids (Skelton, 1994). Capture fishery activities in the Western Province of Zambia are mainly concentrated on the flood plains of the Upper Zambezi (Timberlake, 1997; van Gils, 1988). A total of 98 species were caught in three surveys carried out by the African Wildlife Foundation in the Upper Zambezi River (Mandima and Mwima, 2005). Annex 2 presents information on the scientific, English and local names, as well as the status of threats to the species.

Capture fishing is pursued on both full- and part-time bases, and represents an important economic activity in Western Province. It is reported that 60 percent of households in the Borotse flood plain are involved in fishing activities (Simwinji, 1997). Fish provide an important source of income and protein. Consumption of fish by local residents in Western Province is estimated at about five times the national average (van Gils, 1998). Turpie et al. (1999) report field study results that show that in Lealui district about 75 percent of people claimed to eat fish at least three times per week. The same household survey found that 99.3 percent of households consume fish (Turpie et al., 1999). Another publication reports that only 25 percent of the local fish catch is sold outside Western Province, with 75 percent of fish being sold locally (van Gils, 1988). Fishers and traders dry (sun-dry or smoke-dry using shrubs and leaves) part of their fish catches. This trend has gone up significantly with increased volumes taken by distant traders (who pay fish levies to councils) from the districts.

Capture fishing is highly seasonal but reportedly most effective when the water is receding and from lagoons where fish species are concentrated (Turpie et al., 1999, citing personal communication from D. Kabakwe). The receding floods leave behind various lagoons, lakes and swamps on the flood plains, which provide aquatic habitats for fish such as tigerfish and bream. Nkhata and Kalumiana (1997) report that fishery productivity is determined by flood levels, and that higher floods provide greater opportunities for fish to breed. However, total fish catch is determined by the length of the flood season (van Gils, 1988, as cited by Turpie et al., 1999). Fish catch is highest when water recedes after April and fish species migrate back to the main channels. Fishers continue to fish for several months after the peak months till the onset of the closed season, which runs from December to the last day of February. Fish scarcity occurs during the period of flooding, while the highest catches occur in June and July (Turpie et al., 1999, reporting information gathered during village meetings).

In the Borotse flood plain, fish spawn just before the floods occur. Fish movements in the main Zambezi River channels follow a roughly discernible pattern. Fish species move from the main river channels into the wetlands from December to April, in order to spawn before the height of the floods (in February or March). With the rise of floodwaters, the water becomes turbid with suspended soil. These turbid floodwaters are low in oxygen and only barbel fish species survive. Bream are sometimes killed when turbid floodwaters from the lagoons enter the main channels even though the eggs survive.

In terms of fish catch, it is reported that bream fish species make up 80 percent of the total fish catch (Maimbo et al., 1996). Other fishes caught in smaller amounts in the Borotse flood plain include minnows, tilapia (cichlids), bottlenose (Momelops) and silver barbels (Turpie et al., 1999, citing personal communication from D. Kabakwe). Indigenous fish species desired by people in the Borotse flood plain include bream, which has high commercial value and preferred taste (for example, the red-breasted bream). Tilapia species are also among preferred fish species in the Borotse flood plain. Tilapia species generally contain 19 percent fat (but are low in saturated fat), 81 percent protein and low amounts of sodium ("Nutrition Facts," n.d.). They provide micronutrients, phosphorus, niacin and about 27 calories per ounce (about 1 calorie per gram). Tilapia species have a nutrient balance completeness score[3] of 37 and an amino acid score[4] (denoting quality of protein) of 124 ("Nutrition Facts," n.d.). Farm-raised tilapia species, unlike the captured relatives, contain low levels of omega-3 fatty acids (nutrient value recommended by dieticians) and relatively high omega-6 ("Aquaculture of Tilapia," n.d.). The maize-based feeds given to aquaculture tilapia fish contribute to the higher ratios of omega-6 to omega-3 fatty acids. Barbs and snout fishes also have high commercial value. They are affordable and have preferred taste. Synodontis spp. (squeakers, locally known as "singongi"), Schilbe intermedius (silver catfish, locally known as "mabango"), Clarias spp. and catfish are other consumed fish species. Synodontis spp. (squeakers or "singongi"), juvenile tilapia and silver fish bycatch from illegal fine-meshed draw nets may also be fed to pigs.

Gill nets, set overnight in standing water and lagoons, dominate the fishing practices in the Borotse flood plain (Table 2), accounting for about 75 percent of the total river fish catch. Gill nets are used to fish from the lagoons, created by the receding floods, where the fish remain concentrated (Turpie et al., 1999). Gillnetting intensifies in lagoons and along the edge of the main channel from May until December, when many fishers stop fishing in anticipation of the rains (Chilala, 1968). Traditional "maalelo" traps (comprising a reed and earth weir with conical reed and grass traps) are also used for catching fish in the Borotse flood plain (van Gils, 1988), predominantly when the flood plain is fully inundated. Traps and spears are also used during this period (Chilala, 1968). Apart from these legal traditional fishing methods, the use of illegal fishing methods, such as mosquito nets, threaten fish stocks.

Fish species	Conditions for high catches and availability	Fishing method	Fishing location
Jewel fish	When floods recede and leave behind lakes and streams	Gilled	Simunyange Plains and flood plains
Pike	Low water levels with slow-moving waters (forming rivers and big lakes)	Gilled	Lagoons and vegetated parts of river channel
Red-breasted bream	Flooded plain	Gilled	Rivers, streams and channels
Spotted bream	Mostly during the dry season	Gilled	Long rivers, streams and channels
Banded bream	Rising waters and floods	Gilled	Along rivers, streams and channels
Barb	Dry season	Traps and small-meshed nets	Along rivers, streams and channels
Clarias spp.	Rainy season	Harpooned and gilled	Along rivers, streams, in lagoons and on flood plain

Table 2. Seasonal availability and fishing practices used for catching river fish species in the Borotse flood plain

Capture fishing pressure is so intense throughout the flood plain that fish stocks, including the smallest species, are exploited by widespread use of drifting gill nets, fine-meshed drag nets and large open-water seines, leaving few sanctuaries for fish. This is the case particularly where drifting gill nets are close to the bank and fish sheltering in riverbank vegetation have been driven out of cover by fishers beating the vegetation in advance of the floating net (Mandima and Mwima, 2005).

The intense fishing methods place considerable pressure on both adults and larger juveniles of the larger species to such an extent that people have noted a decline in catch size over the last two decades. This decline has been attributed in the literature to increased use of small-meshed nets (Mandima and Mwima, 2005). Key informants in the fisheries sector see most capture fish species as still plentiful, though with concerns about some species (Table 3).

Scientific name	English name	Local name	Observed trends in availability
Protopterus annectens	Lungfish	Musiyoka and mutome	Seasonal
Marcusenius macrolepidotus	Bulldog	Nembele	Plentiful
Mormyrus lacerda	Western bottlenose	Ndikusi	Plentiful
Borotse Borotseensis	Barbus	Mbala	Plentiful
Labeo lunatus	Upper Zambezi labeo	Linyonga	Seasonal
Schilbe intermedius	Silver catfish	Lubango	Plentiful
Hemichromis elongatus	Banded jewel fish	Lihulungu	Seasonal
Serranochromis robustus	Yellow-belly bream	Nembwe	Seasonal
Serranochromis angusticeps	Thinface largemouth bream	Mamunyandi	Plentiful
Serranochromis altus	Humpback largemouth	Mushuna	Plentiful
Tilapia rendalli	Red-breasted bream	Mbufu	Plentiful
Tilapia sparmanii	Banded bream	Situhu	Plentiful
Oreochromis andersonii	Three-spotted tilapia	Njinji	Plentiful
Ctenopoma multispine	Perch	Mbundu	Seasonal
Sargochromis giardia	Pink bream	Seo	Plentiful
Hydrocynus vittatus	Tigerfish	Ngweshi	Seasonal
Hepsetus odoe	Zambezi pike	Mulumesi	Seasonal
Synodontis species	Squeaker	Singongi	Plentiful
Clarias species	Burble fish	Ndombe	Plentiful
Cyphomyrus discorhynchus	Parrotfish	Minga	Plentiful
Petrocephalus catostoma	Northern churchill	Pepe	Plentiful

Table 3. Capture fish species and observed trends in availability in the Borotse flood plain

A fisher checks gill nets in the morning

Key informants noted concerns about the continued availability of specific capture fish species, namely "nembele" or bulldog (Marcusenius macrolepidotus), "limbala" or barbs (Barbus spp.), and "lipapati" (Tilapia spp.). The market demand for bulldog and barbs (which are small-sized adult fish) has led to increased usage of illegal fine-meshed draw nets, which are non-selective in harvesting young or juveniles of large fish species as bycatch. The use of monofilament nets of mesh size below 5 inches (127 millimeters) and high fishing pressure is also affecting the ready availability of priority indigenous fish species such as "ngweshi" (Hydrocynus vittatusi) and "nembwe" or yellow-belly bream (Serrenochromis robustus), which is a river fish species. Other increasingly scarce river fish species include tigerfish or "ngweshi" (Hydrocynus vittatus) and "mulumesi" or Zambezi pike (Hepsetus odoe). Annex 2 presents additional information on threats to capture fish species, based on International Union for Conservation of Nature red list literature.

To alleviate fish shortages for household consumption, research in development on fisheries sector value chains in the Borotse flood plain suggests complementing capture fishing with fish farming to supplement fish protein (especially during fishing bans), effective fisheries governance and enforcement of the use of correct fishing nets to reduce depletion of fish, and introduction of technologies to reduce fish drying time.

Roles in the fishery sector

Both men and women take part in the fishery sector, together with children, but differences in gender and age group roles occur along the value chain. Turpie et al. (1999) found that men constitute 69 percent of fishers while women represent only 24 percent of fishers. (The remaining 7 percent is ostensibly accounted for by children who engage in fishing.) Table 4 shows predominant gender and age group roles at various economic points along the fish value chain. Capture fish production is dominated by men and youths, with limited women's involvement. Men go out fishing in dugout canoes and use stationary and draw nets to harvest fish for household consumption and sales. Some fish is also used to barter for other goods. The predominance by men in capture fishing is evident in "kuwaya litindi," which involves fish harvesting only by men in September. Traditionally it is taboo for women to fish in the main river channel using dugout canoes and gill nets. Women and children use fishing baskets and mosquito nets to catch small seasonal fish species for household consumption and some sales. Women dominate the fish processing and marketing points along the fish value chain. Analyses of returns to labor by actors along the fish value chain would help ascertain the proportion of rents from market fish pricing captured at points along the fish value chain and substantive differentials between men and women.

Value chain point	Men	Women	Youth	Factors accounting for gender and age group differentiation in roles
Production	XXXX	XX	XXXXX	Physically demanding, traditional gender stereotyping
Processing	XX	XXXXX	XXX	Not very involving, traditional gender stereotyping
Transportation	XXX	X	XXXXX	Physically demanding, traditional gender stereotyping
Marketing	XX	XXXXX	XXX	Women are responsible for household economics
XXXX = very strong role; XXX = strong role; XX = some role; X = slight role				

Table 4. Gender and age group roles along the fish value chain in the Borotse flood plain

Indigenous fish management and governance systems

Based on indigenous knowledge systems, communities have locally formulated bylaws on the management and regulation of fish capture methods, especially in lagoons. Traditionally, most lagoons are owned by the Barotse Royal Establishment and to a lesser extent by communities, and are managed locally by "indunas" (headmen) , princes and princesses. Rights to access main river channels, backwaters and lagoons for fishing are obtained through the "indunas." The governance of actual capture fishing involves both national and traditional authorities. The national government operates a licensing scheme, while village, through the Department of Fisheries, "indunas" grant fishing permissions to fishers to set up fishing shelters upon in-kind or token payments. According to Simwinji (1997), the fisheries sector is essentially open access. As a result, villagers have claimed that outsiders have been entering into fishery at will (Turpie et al., 1999). The traditional and state methods of managing fisheries have not been very effective. Key challenges to the management of common fish resources include illegal and unsustainable fishing practices, lack of harmonization between management systems by government agencies and traditional authorities, lack of a sense of ownership and responsibility for the fish resources by communities, and lack of fish resources management bylaws in communities. The AAS research-in-development program, acting as an honest broker, could bring together key stakeholders in fisheries sector governance and the communities to investigate how to plug currently observed regulatory gaps. For example, stakeholders could develop and test improved governance and regulatory models built on the strengths of both the traditional authority system and national fisheries policy guidelines. The objective of the improved fishery governance and regulatory model would be to facilitate effective localized implementation of sustainable fishing practices, closed seasons, and enforcement of fishing policies such as fishing nets and licensing requirements. Fisheries experts in Western Province suggest that social norms, governance, and regulatory mechanisms and policies that are likely to foster sustainable river fish management include actualization of Fisheries Management Committees or Village Management Committees in villages and fishing camps in "silalos," introduction of fish breeding zones or areas that are permanently closed for fishing, and strengthening of local governance systems in natural resource management.

Aquaculture in the Borotse flood plain

In most of the Borotse flood plain, except for in Kaoma district, aquaculture is a relatively new technique. The main fish species farmed, primarily for household consumption and sometimes for sale, are Tilapia rendalli or red-breasted bream (30 percent), Oreochromis macrochir or green-headed bream (10 percent), and Oreochromis andersonii or three-spotted bream (60 percent). Gender differentials in aquaculture exist because men operate as individuals while women operate in groups. This differential is partly dictated by the nature of the work involved in manual construction of fish ponds, as well as access to and availability of suitable land. Pond construction is restricted to the dry periods of the year for new ponds, while pond management continues all year round. Aquaculture practices in the Borotse flood plain include the use of rice bran, maize bran, cassava leaves, sweet potato leaves and green vegetables as feed, given twice a day to the fishes. Aquaculture fish are harvested at maturity, six months and beyond after the ponds are stocked. There is no processing of the fish harvested. Unlike capture fish, aquaculture fish are not fed to livestock. The key constraints to effectiveness of current aquaculture practices in the Borotse flood plain include the following: lack of high-quality fingerlings, poor nutritional value of fish feed ingredients, high cost of commercial feed, poor slope of prevailing flat lands with the result that most ponds utilize underground water and are unable to drain completely, and high seepage levels due to predominantly sandy soils.

Photo Credit: Conrad Muyuale/Catholic Relief Services

Chicken roaming in village compound

LIVESTOCK RESOURCES

Table 5 presents predominant livestock resources, the purposes for which they are kept, gender management roles and feeding practices. The Lozis traditionally keep herds of cattle as part of their farming system and livelihood strategies. The cattle provide draft power for plowing fields, manure for fertilizing fields, milk, and cash when an emergency arises (Gershon et al., 2012). Livestock are typically sold only when household members need to pay large sums of money for goods and services. However, this is changing, and there is increased participation in cattle marketing as a source of income.

The Borotse flood plain contains some of the most productive areas in Zambia for raising cattle. In Mongu district, the geographical distribution of cattle shows concentration in and around the flood plain. The highest settlements are on the edges of flood plains, including both the Zambezi flood plain and the Luena flood plain. Here both good grazing land and water are available. Under a transhumance system in which cattle and other livestock are moved between the flood plains and adjacent upland areas, livestock owners move their animals to higher ground during the flood season and then move back to the flood plains after the floods recede. The length of the upland grazing period depends on the time it takes for the floods to recede in the flood plain. Usually, pressure on upland range resources and feed quality affect the condition of the animals, since grazing and browsing constitute over 90 percent of overall feed resources. Crop residues are only available in very limited periods soon after harvest. Where communal grazing land is beyond the carrying capacity of cattle numbers, transhumance brings with it overgrazing, deforestation, and the confining of cattle to a reduced area during the rainy season in order to avoid quarrels as a result of crop damage.

Livestock type	Breed	Purposes for which they are kept	Management roles	Feeding practices
Cattle	Borotse breed, crosses (between Borotse breed and barom cattle); not much in terms of dairy cattle	Prestige, sale when needy, manure, meat, hides, draft power, milk from indigenous cattle	Managed by males but women plus youth play role as caretakers with limited or no power over stock	Traditional free-range grazing systems on communal lands by herders; no deliberate feeding; only few cases of supplements; not much attention paid to feeding and welfare regimes
Goats and sheep	Local, Boer, and crosses	Meat, hides	Owned mainly by women	Free-range browsing; scavenging on crop stover
Village chicken	Indigenous	Meat, financial backup	Managed by women	Scavenging on human food and crop remains
Ducks	Indigenous	Meat	Same as for chickens	Scavenging on human food and crop remains
Pigs	Crosses with landrace, large white, indigenous black	Meat	Men and women have almost equal ownership and management roles	Scavenging for food

Table 5. Livestock types, breeds, feeding practices and management in the Borotse flood plain

Photo Credit : Sibeso Mulele/Ministry of Agriculture and Livestock, Mongu, Western Province, Zambia

Cattle graze in the Borotse flood plain

The indigenous or traditional livestock husbandry in the Borotse flood plain relies on ethno-veterinary resources to treat sick animals. The treatment of sick animals is usually the domain of the heads of households, especially the males or fathers. Indigenous livestock knowledge systems are limited to older people in the communities.

The main cattle production constraints in the Borotse plains are the limited grazing time, especially during floods, and inadequate nutrition. There is also a huge worm burden, especially liver fluke, which is worsened by the transhumant nature of the people and their livestock. A consistent de-worming program is required to alleviate productivity constraints due to the worm burden. There is a general lack of modern skills and knowhow of general principles and norms governing livestock rearing and welfare. The assessment of cattle resource management suggests that improvements in cattle productivity may require individual and community-led initiatives to improve nutrition through feed supplementation, disease control and adoption of modern husbandry practices.

Goats are predominantly kept by the Mbunda and Luvale tribes, and only recently by Lozis through interventions by projects. Limited browsing space for peripatetic stock poses a challenge to integrated livestock systems. This is because the rearing of goats sometimes raises conflicts, since it can be seen as a nuisance. Local chickens, predominantly kept by women, suffer seasonal wipe-outs from diseases such as Newcastle disease. The introduction of vaccination programs has had a positive impact, although there is inadequate availability of vaccines.

Pigs are also raised, but they mainly roam freely, scavenging for food.

Predominant diet components and food consumption prohibitions

Table 6 presents expert assessment of the typical diets of men, women and children. Households in the Borotse flood plain access food through a variety of sources, including domestic production, gathered wild foods, purchases from markets and food for work where available. Diets in both urban and rural communities are dominated by energy-dense foods such as "nsima" (thick paste prepared from either maize or millet meal), cassava and sweet potatoes. Such carbohydrate-rich foods are often eaten with vegetable relish, which may also contain some protein (where fish, meat, insects, etc. are included in the relish). Meals served to children in rural communities include some sour milk. Gershon et al. (2012) noted that despite the diversity of food sources, actual food availability is highly seasonal. From August or September to February (known as the "hunger season") food availability is mostly limited, and households are generally not self-sufficient in food. Fish is an essential part of household diets in the Borotse flood plain. The commonly consumed species include breams, barbel fish (eaten by all), tigerfish (eaten by all), bulldog ("nembele"), "limbala" (eaten by all) and "mbundu" (not eaten by women). Pregnant women are prohibited from consuming red-breasted bream. Apart from traditional factors, other social factors that influence fish consumption in the Borotse flood plain include religion (e.g., Seventh Day Adventist adherents do not eat fish without scales), lack of scientific knowledge, and economic factors such as the effects of increase in population and the influence of increasing fish demand from outside the province on fish prices, which make fish less affordable than before.

Time of meal (urban and rural)	Adult men	Women	Children 0.5–6 years
Early morning (urban)	Tea and bread or scones, rice	Tea and bread or scones, rice	Maize meal porridge with groundnuts or milk, tea and bread or scones, rice
Early morning (rural)	Usually nothing	Usually nothing	Roasted cassava, leftover maize or millet or cassava meal with relish,* sweet potatoes
Afternoon meal (urban)	Maize meal and relish*	Maize meal and relish*	Maize meal and relish*
Afternoon meal (rural)	Maize, millet or cassava meal with relish,* sweet potatoes	Maize, millet or cassava meal with relish,* sweet potatoes	Maize, millet or cassava meal with relish,* sweet potatoes
Snack (urban)	Fruits when available	Fruits when available	Maize meal porridge with groundnuts or fresh or sour milk, teamed with bread or scones, rice, biscuits, fruits, "samp"**
Snack (rural)	Roasted cassava, sweet potatoes, fruits, "samp,"** "maheu,"*** porridge with sour milk ("ilya")	Roasted cassava or groundnuts, sweet potatoes, fruits, "samp,"** "maheu,"*** porridge with sour milk ("ilya")	Roasted cassava or groundnuts, sweet potatoes, fruits, "samp,"** "maheu,"*** porridge with sour milk ("ilya")
Evening meal (urban)	Maize meal or rice and relish*	Maize meal or rice and relish*	Maize meal or rice and relish*
Evening meal (rural)	Maize or millet meal with relish, sour milk or both	Maize or millet meal with relish, sour milk or both	Maize or millet meal with relish, sour milk or both

*Relish consists of different vegetables, fish, eggs, insects and meat (that is, beef, pork, goat meat, poultry, etc.).

**"Samp" is coarsely crushed maize that is dehulled. It may be mixed and consumed with one of the following: sugar, salt, whole groundnuts, groundnut flour, sour milk, vegetables, and meat or any relish available.

***"Maheu" is a locally brewed energy drink made from maize meal and local herbs.

Table 6. Typical diets of residents of rural and urban communities in the Borotse flood plain

Although a wide variety of livestock products (chicken, eggs, ducks, pigeons, milk and meat from cattle, and meat of goats and pigs) are consumed by households in the Borotse flood plain, key informants pointed out that women experience some food consumption restrictions informed by unproven beliefs. For example, women are discouraged from eating eggs based on the belief that they could get bald heads when they eat eggs. Yet eggs contain diverse vitamins and minerals, as well as some essential micronutrients, such as selenium, that are needed by the human body. Annex 4 presents some nutritional facts about eggs, which show the benefits (source of riboflavin, vitamin B12 and phosphorus, as well as a very good source of protein and selenium) and negative aspects (high in saturated fat and very high in cholesterol) of eggs. Since eggs contain some nutritionally desirable elements, social and gender analyses of the Borotse flood plain communities may want to explore further the scope for overcoming traditional beliefs that bar women from the consumption of eggs. The key informants also noted that pregnant women are prohibited from eating offal (particularly the intestines) of livestock and some fish species. In the case of the fish species, it would be pertinent to compare the nutritional profiles of fish species that women can consume to those species whose consumption is prohibited by local customs and traditions. If adequate fish species replacements for those on the consumption prohibition list exist and are accessible to women, then there may be no need to worry about the prohibitions.

No evidence of gender restrictions were reported with respect to the consumption of products (such as wild vegetables) from non-tree species harvested from the wild. Similarly, there is no known gender-based prohibition against the consumption of produce (such as fruits) from tree species. Caterpillars, other edible insects and several types of edible fungi are collected and consumed by all family members without gender restrictions. Generally, the mushrooms found are the following:

- Chanterellus spp. (of which there are four types; namely, C. miniatescens, C. cibarius, C. longisporus and C. densifolius), commonly called in Lozi "ndwindwi," "mwamba-lindondwe," "chitondwe," "lindondwe" and "matwianshangwe").
- Russulaceae family — principally the Lactarius spp. (such as L. kabansus, L. gymnocarpus, C. piperatus), called locally in Lozi "sichikwele," "nakandama" and "kambande."
- Schizophyllum commune (called locally in Lozi "silutoko," or "sepa" in Bemba).
- Other unidentified mushrooms collected locally, called in Lozi "bionde," "bushele," "liluwe," "sibiti," "kashimbandala" and "sitongwani"; most mushrooms are currently collected from the wild.

Improving diets in the Borotse flood plain

Gershon et al. (2012) found that at Mweeke, while women ranked meat, fish and most green leafy vegetables as highly nutritious foods, they had some misperceptions about the nutritional value of fruits (with the exception of oranges), while energy-dense rice and maize were ranked as very nutritious. This may point to gaps in nutrition education and the need for local nutrition experts to explore avenues (such as antenatal visits or visits by community healthcare experts to villages) to disseminate knowledge about the known nutritional value of fruits, as well as the need to balance consumption from the various food groups.

Local nutrition informants surveyed in Western Province suggested that the consumption of vegetables such as "libowa" (Amaranthus spp.), "sindambi" (Hibiscus spp.) and "sishungwa" (Cleome gynandra) could improve diets. Also, parts of wild plants such as "mumbole" or "mumonsomonso" (Vangueriopsis lanciflora), "mulutululwa" (Ximenia caffra), "mahululu" (Strychnos cocculoides), "namulomo" (unidentified), and "mungongo" (Rucinodendron rautanenii) could help improve the quality and diversity of diets. Annex 1 presents botanical names and corresponding Lozi vernacular names. The nutritional contents, as well as any anti-nutritional factors, of these locally available vegetable plant species require careful investigation and documentation for use in nutritional education in schools and in hospital outlets frequented by women for ante- and postnatal care.

Local nutrition informants also suggested that nutrient-dense indigenous species that could be used to improve diet quality and diversity include "mugongo" (Rucinodendron rautanenii), used as cooking oil; "mubula" (Parinari curatellifolia), used in preparing drinks, oil and cakes; and sorghum and millet, which are crops well suited to the soils in the Borotse flood plain. Cowpeas (Vigna unguiculata), soybeans (Glycine max.) and groundnuts (Arachis hypogaea) are non-indigenous crop species that could contribute to improving diets in the Borotse flood plain because of their plant protein contents.

INDIGENOUS AND LOCAL KNOWLEDGE ON MANAGEMENT SYSTEMS

Indigenous or local knowledge systems on the management of crops and varieties in the Borotse flood plain are passed on from adult custodians to the youth. The adult custodians recommend the planting of maize on "mazulu" land types in November or "litapa" land types in September. They also recommend planting the rice variety "supa" in deep water, while the rice variety "zawa" is to be planted in shallow water. Based on indigenous knowledge, "zawa" is used to make "buhobe," the local staple, while "supa" is cultivated mainly for sale. The key informants suggested that crop production and yields are assured when local knowledge systems are followed in matching land types to specific crops and water availability. To do otherwise is to risk crop failure. For example, if "supa" is planted in shallow waters, there could be no rice-grain filling due to lack of water. This is good advice, which the AAS productivity thematic area may want to take into consideration in the participatory design of interventions to be tested in the Borotse flood plain.

Potatoes in family cooking pot

ENVIRONMENTAL ISSUES

Plowing and pulverization of the soil accelerate loss of organic matter, damage soil structure, and expose topsoil to erosion by rainwater and wind and nutrient loss through runoff water. Key informants surveyed pointed to other specific environmental issues as impinging on biodiversity resources in Borotse flood plain:

- Land degradation, which reduces soil capacity to provide environmental services to plant life, including reduced levels of nutrients.
- Deposition of silt and sediments eroded from lands elsewhere.
- Soil mining, resulting from non-replenishment
- of nutrients depleted for crop production, particularly where crop residue is not returned to the soil.
- Bush fires, used for clearance of forest vegetation cover for cultivation, as well as to stimulate re-growth of grasses for feeding livestock. Late burning destroys re-growth, desiccates trees and wipes out non-fire-tolerant species, leading to changes in species composition. Where bush fires affect grasses in "dambo," communities that depend on sales of grasses lose a source of income.
- Overgrazing of communal rangelands by cattle numbers beyond carrying capacity.
- Shifting cultivation practices by farmers.

Photo Credit: Conrad Muyuale/Catholic Relief Services

Mangoes on a tree in the Borotse flood plain

Synthesized insights

Overexploitation of biodiversity species occurs when humans use a particular species or group of species beyond the point where those species can replace themselves (Timberlake, 2000). Fish species harvested from the Borotse flood plain, wild vegetables, and other products extracted from forest resources are under severe exploitation pressure. The fish value chain research in development may want to link up with all relevant stakeholders to explore effective capture fishing governance and constraints to aquaculture. Sustaining natural forest resources will depend on developing alternative income-earning opportunities to resource-depleting activities such as making charcoal and curios from wood.

In addition, analyses of the value of current forest resources, such as mushrooms and non-timber forest products that could be lost if natural forests are depleted, would be helpful in galvanizing communities and their leaders to put in place effective local governance of natural resources. Key informants suggested that options for improving livelihoods in the Borotse flood plain could include beekeeping, more systematic cultivation of mushrooms (to take advantage of the good market for mushrooms), the planting of woody perennials such as pigeon pea (seeds for food, leaves for fertility improvement and woody parts for firewood) and Gliricidia sepium, and new crops such as sunflower (to take advantage of developing market opportunities). AAS research in development on natural resources management could explore community-led initiatives to promote sustainable access and use of ecosystem services, such as the provision of mushrooms associated with woodlands and termite activity.

Farmers are unable to predict flooding levels in any one year. AAS research-in-development efforts may be directed at enhancing predictability of flooding levels and putting in place a sustainable mechanism for predicting and informing residents of the flood plain about the likely commencement and retreat of floods. Until there are reasonable means to predict flooding, farming practices have to adapt to the vagaries of the floods. This may require participatory investigation and design of feasible options for farmers to use based on indigenous knowledge of the potentials and risks associated with different land types available to farmers in the Borotse flood plain. Farmers have responded to flooding risk to crops by shifting from maize to rice with increased flooding. However, high regular floods are likely to wipe out some crops such as pumpkins (Cucurbita moschata) from the fields where they are normally cultivated. The AAS productivity thematic area may want to work with all stakeholders to identify threatened crops and explore potential alternative sites for cultivation of the flood-threatened desired crops. The low yields of the major cultivated crops (rice, maize, sorghum, millet, cassava, etc.) point to opportunities for productivity improvements involving early-maturing varieties, as well as matching varieties to flooding regimes for the different land types and rains, timely availability and access to high-performing seeds, soil amendments to enhance nutrient availability, and cultural practices to control weeds in the fragile wetland ecosystem and optimize planting. The AAS productivity thematic area may want to work with partners in the hub to explore participatory design of community-led agronomic studies that will seek to overcome current constraints to crop productivity and levels of food production, as well as increase access to and improve utilization of limited soil amendments. We could also benefit from indigenous knowledge shared by key informants to improve crop production systems through testing changes to crops and the cropping calendar; e.g., planting maize varieties before the rains in the "sitapa" fields, utilizing maize varieties that keep cobs high above floodwater line, and growing sorghum varieties that tolerate flooding for months (just like rice) in areas prone to flooding.

Gender differentiation in access to resources and participation in economic opportunities, where they occur, have been highlighted in this paper. The AAS gender thematic area may want to explore, with the help of local women's groups and traditional authorities, how best to overcome discriminatory practices against women and enhance mutually beneficial roles between genders.

Recommendations

A common basic problem in the Borotse flood plain is that many households do not produce enough food to sustain them for a year. Adopting a problem tree approach, the follow-up focus group discussions in the 10 AAS communities could explore factors that may be contributing to inadequate food resources. These factors could include lack of access and lack of timely availability of high-performing seeds, poverty, lack of soil amendments and plowing services to cultivate lands, and lack of capacity to manage fields from sowing to harvest and beyond. Also, the follow-up individual household surveys could explore the linkages between the different land types and food gaps experienced by households. In fulfillment of the AAS development challenge, further agrobiodiversity research-in-development activities may explore specific sets of holistic innovations, such as training in revolving domestic savings (piloted by Caritas), local seed production and distribution, and a focus on strong marketable produce, which could more tightly link rural communities to private sector actors through market operations. Bioversity could lead participatory design and implementation of rural seed initiatives (conservation and availability) to facilitate local access and examine with Catholic Relief Services, Caritas and other intervention matrix partners how to empower poor farmers to facilitate access to preferred high-performing hybrids. Another critical element that needs to be addressed is improvement in the productivity of the crop-livestock system (both the nutrient- and organic-matter-poor sandy soils and cattle feed when livestock are moved to upland areas at the onset of floods). To respond to the associated constraints, appropriate multiple-purpose pigeon pea and groundnut varieties could be tested for their suitability and acceptance by farmers in the Borotse study villages.

Banana plants in a vegetable garden in the Borotse flood plain

NOTES

1 "Dambos" are complex, shallow wetlands generally found in flat, higher rainfall plateau areas, with river-like branching forms that may be nowhere very large, but common enough to add up to a large area.

2 A copy of the questionnaire is available from the first author and the AAS knowledge management database upon request.

3 Nutrient balance completeness score ranges from 0 to 100. This score essentially tells you how close the food is to filling your needs for all essential nutrients. See http://nutritiondata.self.com/help/nutrient-balance-indicator#ixzz2gSETaD91

4 Amino acid scoring provides a way to predict how efficiently protein will meet a person's amino acid needs. This concept assumes that tissue protein synthesis is limited unless all required amino acids are available at the same time and in appropriate amounts at the site of tissue protein synthesis.

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Annex 1. Glossary of economic biodiversity resources in vernacular (Lozi) with English and botanical names for plants

Lozi names of species	Common or English names	Corresponding botanical names
Delele	Okra	Abelmoschus esculentus and Hibiscus esculentus
Manawa	Cowpea	Vigna unguiculata (L.) Walp
Mabele	Sorghum	Sorghum bicolor
Mbonyi	Maize	Zea mays
Mauza	Pearl millet	Pennisetum glaucum (L.) R. Br.
Makonde	Banana	Musa spp.
Libowa	Amaranthus	Amaranthus spp.
Libowa, green	Amaranthus, green	Amaranthus spp.
Libowa, red	Amaranthus, red	Amaranthus spp.
Mundalangwe	Pumpkin	Cucurbita pepo or Cucurbita moschata
Likomu	Cattle	
Likuhu	Chicken	
Likulube	Pig	
Lipuli	Goat	
Litapi	Fish	
Makaka	Guinea fowl	
Simbangala	Cashew nuts	Anacardium occidentale
Simbita	Pineapple	Ananas comosus
Sindambi	Hibiscus	Hibiscus spp.
Sishungwa	Cat's whiskers or African cabbage	Cleome gynandra
Lituu	Bambara groundnuts	Vigna subterranean or Voandzeia subterranean (L.) thousars
Kwaba	Guava	Psidium spp.
Mango	Mango	Mangifera indica L.
Lemoni	Lemon	C. limon (L.) Burm.f.
Olonji	Orange	Citrus spp.
Mushwati	Sugarcane	Saccharum officinarum L.
Mwanja	Cassava	Manihot esculenta
Ngulu	Sweet potato	Ipomoea batatas
Ndongo or ndongo musoswane	Groundnut	Arachis hypogaea
INDIGENOUS WOODY	SPECIES	
Isunde	Jasmine pea or sand camwood	Baphia massaiensis
Mahuluhulu		Strychnos cocculoides
Mahwahwa	Spine-leaved monkey, orange	Strychnos pungens
Mubula		Parinari curatellifolia
Mukuwa		Copaifera baumiana
Mumonsomonso or mumbole		Vangueriopsis lanciflora

Lozi names of species	Common or English names	Corresponding botanical names
Mungongo		Ricinodendron rautanenii (Schinziophyton rautanenii)
Munjongolo	Batoka jackal-berry or sand jackal-berry	Diospyros batocana
Munyelenyele		Ochna pulchra
Muzauli	African rosewood	Guibourtia coleosperma
Musekese		Piliostigma thonningii
Manganda	African palm	Hyphaene ventricosa
Mulutulwa	Large sour plum	Ximenia caffra
Mukusi	Zambian teak or Zambezi redwood	Baikiaea plurijuga
Mwande		Afzelia quanzensis
Mulombe (mukwa)		Pterocarpus angolensis
Mutuya		Brachystegia spiciformis Benth.
Mukelete	African blackwood	Dalbergia melanoxylon
Munganyama	Purple-leaved albizia	Albizia antunesiana
Mukenge	Large-fruited bushwillow	Combretum zeyheri
Namulomo	Unidentified	
Sipupu	Unidentified	
MUSHROOMS		
Ndwindwi		Chanterellus spp.
Silutoko		Schizophyllum commune
Bushele	Unidentified	
Liluwe	Unidentified	
Sibiti	Unidentified	
Nakandama		Lactarius spp.
Mambwalindondwe		Chanterellus spp.
Sichikwele		Lactarius spp
Kashimbandala	Unidentified	
Sitongwani	Unidentified	
Mudambi		Hibiscus spp.
Libowa	Amaranths	Amaranthus spp.
Sishongua	Unidentified	
Siku	Unidentified	
NON-PERENNIAL PLANT	SPECIES	
Mampana	Edible potato-like food found in water	
Linjefu	Water nut	Dalbergia melanoxylon
		Albizia antunesiana
Mashela	Water lily	Combretum zeyheri
	Nymphaeaceae family	
Malumba	Large roots (type of water lily)	
Litindi (vegetable)	Unidentified	
	Rape	Brassica napus L.

Source of botanical names of woody plants: Fanshawe, D.B. (1956). Check list of vernacular names of the woody plants of Zambia. Forest Research Bulletin No. 3. Republic of Zambia.

Annex 2. Scientific, English and local names of river fish species caught in the Borotse flood plain and documented status of threats to them

No.	Scientific name	English name	Local name	Threats*
1	Protopterus annectens spp. Brieni	Lungfish	Musiyoka or mutome	No threats are known to be currently affecting this species.*1
2	Marcusenius macrolepidotus	Bulldog	Nembele	There are no major threats for this species.*2
3	Mormyrus lacerda	Western bottlenose	Ndikusi	The species has no immediate threats, although it is specifically targeted by fishers using hook and line.*3
4	Borotse Borotseensis	Barbus	Mbala	Given the wide distribution and extensive suitable habitat, there are no major threats to this species.*4
5	Labeo lanatus	Upper Zambezi labeo	Linyonga	No information.
6	Schilbe intermedius	Silver catfish	Lubango	Schilbe intermedius is commercially used in aquaculture. There is heavy fishing pressure but the species is highly abundant and fecund.*5.
7	Hemichromis elongatus	Banded jewel fish	Lihulungu	The species has a widespread distribution in large rivers and thus there are no major threats.*6
8	Serranochromis robustus ssp. Robustus	Yellow-belly bream	Nembwe	Fishing of this subspecies is unlikely to be having a major impact at the moment, although could increase in the future.*7
9.	Serranochromis angusticeps	Thinface largemouth bream	Mamunyandi	Serranochromis angusticeps is commercially used for aquaculture.*8
10.	Serranochromis altus	Humpback largemouth	Mushuna	No known threats. Restricted almost entirely to the edges of main river channels and deep connected lagoons in fringing vegetation (Skelton, 2001; Tweddle et al., 2004). Winemiller (1991) classed the species as a river-dwelling crepuscular piscivore.*9
11.	Tilapia rendalli	Red-breasted bream	Mbufu	The major threats to this species are increased fishing pressure and loss of vegetated margins and flood plains around rivers and lakes due to agriculture extension.*10
12.	Tilapia sparrmanii	Banded bream	Situhu	Tilapia sparrmanii is a species that is commercially used for aquaculture, and there is potential for overfishing.*11

13.	Oreochromis andersonii	Three-spotted tilapia	Njinji	The spread of alien Oreochromis niloticus (L.) as a result of aquaculture introductions in the Kafue and Upper Zambezi catchments is a major threat to the survival of O. andersonii throughout its range (Tweddle et al., 2004). Increasing fishing effort and increasingly widespread use of small-meshed fishing nets have depleted stocks in many areas, such as the heavily populated areas of the Borotse flood plain on the Upper Zambezi River in Zambia. Flood plain lagoons no longer provide refugia as they are all intensively seine netted.*12
14.	Ctenopoma multispine	Perch	Mbundu	No major threats known; however, it has commercial importance as an aquarium fish. Tweddle et al. (2004) observed it moving out from the Zambezi River onto newly flooded grasslands; e.g., they recorded 62 specimens from a single mat of grounded vegetation on the overflowing riverbank.*13
15.	Sargochromis giardi	Pink bream	Seo	No known threats.*14
16.	Hydrocynus vittatus	Tigerfish	Ngweshi	Tigerfish have declined in some rivers in southern Africa due to pollution, water abstraction and obstructions such as dams and weirs that prevent passage. Unregulated gillnet fisheries locally threaten the species.*15
17.	Hepsetus odoe	Zambezi pike	Mulumesi	Hepsetus seems to prefer the upper courses of small rivers where Hydrocynus is absent or less abundant. A major threat is its collection commercially as aquarium fish.*16
18.	Synodontis sp. nov. "Lower Tana"	Squeaker	Singongi	No information available.*17
19.	Clarias stappersii	Burble fish	Ndombe	Clarias stappersii is a demersal species that occurs in well-vegetated, sluggish river channels and flood plain lagoons. It is more common in northern Upper Zambezi tributaries. No major threats are known.*18
20.	Cyphomyrus discorhynchus	Parrotfish or Zambezi parrotfish	Minga	This species has commercial importance as an aquarium fish. There is also risk of overfishing (particularly in lakes); illegal fishing, especially by use of poisons and small-meshed nets across rivers, threatens this species.*19
21.	Petrocephalus catostoma	Northern churchill	Pepe	Threat of predation by larger avian predators; common in flood plain habitats.

Source: Fish list, personal communication from Numel Phiri, Fisheries Department, Mongu, Western Province, Zambia.

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Annex 3. Nutritional value of egg (whole, raw, fresh)

Percent Daily Value: Carbohydrates, 2%; Fats, 63%; Protein, 35%.

Estimated glycemic load = 2

Calories, 1453 kJ; Protein, 30.6 g; Total carbohydrate, 1.9 g; Saturated fat, 7.5 g; Monounsaturated fat, 9.3 g; Polyunsaturated fat, 3.3 g; Total omega-3 fatty acids, 180 mg; Total omega-6 fatty acids, 2789 mg.

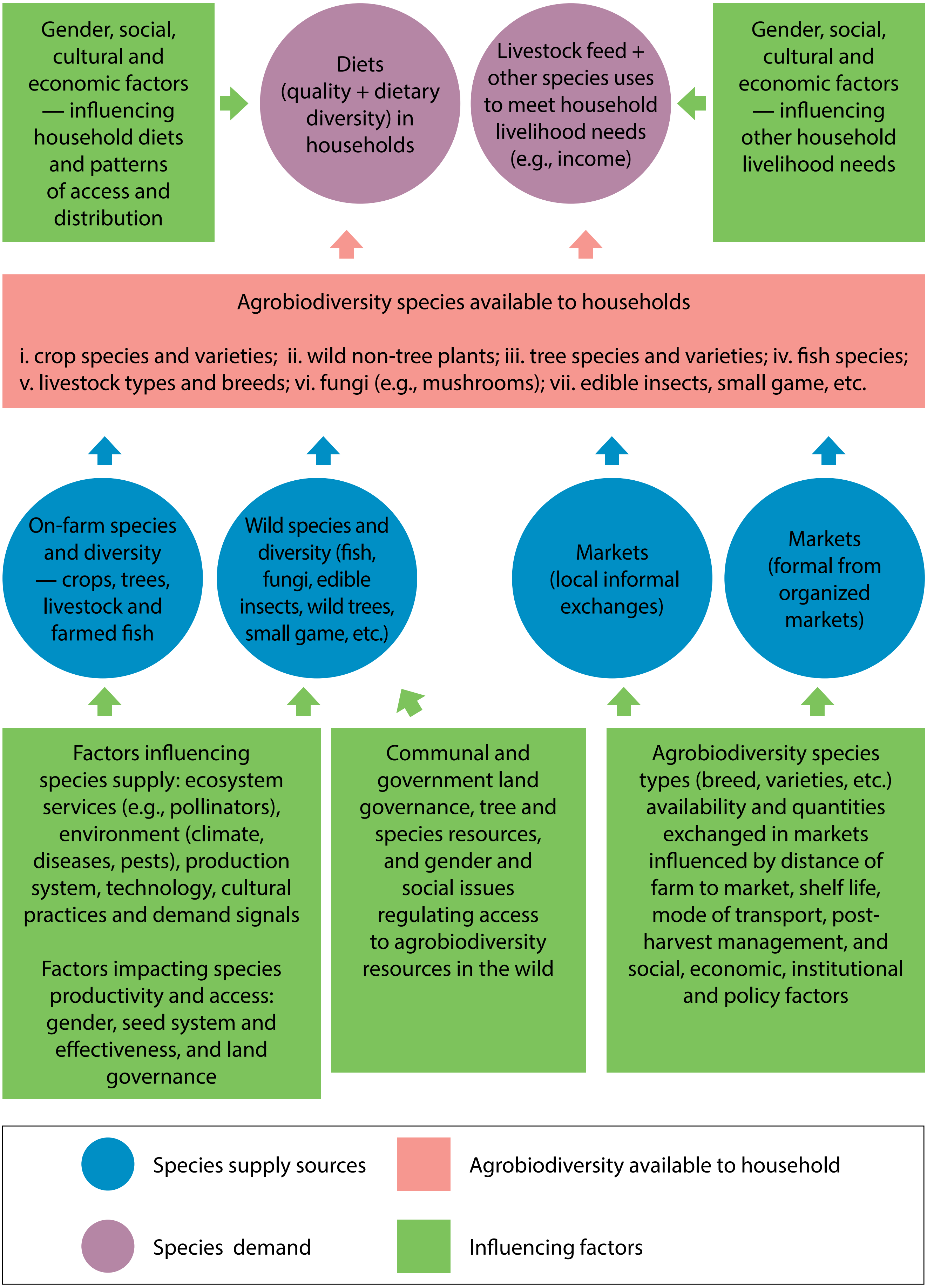
Nutrient balance: completeness score = 50; amino acid score = 136

Vitamins: A, 1183 IU; D, 85.1 IU; E (Alpha Tocopherol), 2.4 mg; K, 0.7 mcg; B6, 0.3 mg; B12, 3.1 mcg; Folate, 114 mcg; Thiamin, 0.2 mg; Riboflavin, 1.2 mg; Niacin, 0.2 mg; Pantothenic acid, 3.5 mg; Choline, 610 mg; Betaine, 1.5 mg.

Minerals: Calcium, 129 mg; Iron, 4.4 mg; Magnesium, 29.2 mg; Phosphorus, 464 mg; Potassium, 326 mg; Sodium, 340 mg; Zinc, 2.7 mg; Copper, 0.2 mg; Manganese, 0.1 mg; Selenium, 77 mcg; Fluoride, 2.7 mcg.

Source: Nutrition facts and analysis for egg, whole, raw, fresh. (n.d.) Retrieved from http://nutritiondata.self.com/facts/dairy-and-egg-products/111/2

Annex 4. Conceptual framework for agro biodiversity baseline studies in the borotse floodplain system



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