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ABS Provides Opportunities for Indigenous and Local Communities in the Limpopo National Park. An ethnobotanical survey of plants used by the Changana community, Limpopo National Park, Mozambique

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Research

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Abstract

Background: Genetic resources are important for the livelihood of the rural population in developing countries and have an economic potential that, through an efficient *Access and Benefit Sharing* regime, can support sustainable economic development. Considering the wealth of genetic resources in Mozambique, its eligibility for Access and Benefit Sharing projects has been explored.

Methods: The socio-economic status of the Changana community of the Limpopo National Park area was studied through a 500 questionnaires socio-economic survey. Considering the livelihood role that plant genetic resources could play for the local rural population, an ethnobotanical survey was conducted, with the support of villagers knowledgeable of wild plant resources and their use.

Results: Several criticalities in the living condition of local communities and a generalized lack of adequate economic incomes have emerged from the socio-economic analysis. A list of 101 plant species with important commercial possibilities, mainly related to medical, food and cosmetic sectors, was provided by the ethnobotanical survey. Around 95% of the plant studied which could have effective medical properties showed the greatest potential.

Conclusion: A significant potential for Mozambique to be included in Access and Benefit Sharing initiatives was recognized. The present work can contribute to the identification of Access and Benefit Sharing pilot projects, toward the evaluation of the policy efficacy and implementation of the Nagoya Protocol in the Country. The Limpopo National Park area can support Access and Benefit Sharing projects toward the economic development of the indigenous and local communities and the conservation of the Country's biodiversity.

Introduction

In line with the *Convention on Biological Diversity* (CBD), this work is aimed at promoting the conservation and sustainable use of Mozambique's genetic resources (GR) and the achievement of a fair and equitable sharing of the benefits arising out of their use [40], while contributing to the Country's sustainable economic development.

Around 54,7% of the Mozambican population lives below the poverty line [28] and, as reported by the World Bank [38], around 66% of the Country population of 28 million, lives and works in rural areas. Mozambican national and rural economies depend heavily on the goods and services provided by biodiversity [26]. The biodiversity richness of the Country emerges from the high diversity of its four main natural ecosystems (terrestrial, marine, coastal and interior water) and five dominants biomes (1. Arid and semi-arid forests; 2. Tropical and subtropical rangelands with savannas, thickets and woodlands; 3. Floodplains and savannas; 4. Mountain grasslands with thicket; 5. Mangroves). Floristically there are four phyto-geographic regions. Around 70% of the land is covered with vegetation: 51% of forests and 19% of other types of woody vegetation. Recent studies indicate the presence of 5.781 species of plants, including 800 endemic or nearly endemic, which represent an important resource for communities in terms of food, medicinal products, construction equipment, and power supply [28].

Considering the CBD's definition of GR, as "genetic material of actual or potential value" [40], and the wide traditional use of Mozambique's plant genetic resource, these can expectedly provide the raw material for the development of new commercial products for the pharmaceutical, agricultural and cosmetic sectors. Through the implementation of the *Access and Benefit Sharing* (ABS) principles, introduced by the CBD and then expanded by its additional protocol: *The Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization to the Convention on Biological Diversity* (NP) [2], it is possible to achieve a fair and equitable sharing of benefits associated to the use of GR. Thus, this work builds on the contention that an efficient ABS regime may represent a tool for sustainable utilization of biodiversity toward economic development, while contributing to alleviate poverty [17] and meeting the indigenous people's basic needs [36].

A valid example is provided by *The Hoodia gordonii case*. Such plant has long been used by the San peoples for its appetite suppressant qualities, while serving both as food and water source. Information on its use by the San, guided the Council for Scientific and Industrial Research (CSIR) of South Africa in a research and development project [6; 1]. This project led to the

production of an appetite suppressant drug, called “P57”, with an estimated market potential of more than 6 million of USD [21]. After a long negotiation, CSIR recognized the San people as holders of traditional knowledge (TK) associated with Hoodia and an ABS agreement was signed [6]. Basing on such agreement, the San will receive 6% of all royalties going to CSIR, and 8% of the CSIR’s income from the commercialization of the product, when certain targets will be reached [21].

Considering the availability of plant resources in Mozambique and their importance for the national economy besides for that of the rural population (90% of rural energy comes from wood, while around 80% of population uses medical plants and several non-timber products for its sustenance [28; 26]), the aim of the present work has been to assess their potential as well as the Country’s eligibility for ABS projects. Consistently, we have intended to contribute to the identification of a pilot project as case study to evaluate the policy efficacy and the implementation of the NP in the Country, as requested by the *ABS Clearing-House* in the Interim National Report on the Implementation of the Nagoya Protocol [37]. To this end, our research has included an assessment of the potential of the Limpopo National Park (LNP) area to support a pilot project, through a socio-economic survey, aimed at outlining the living conditions of the Indigenous and Local Communities (ILCs) inside the Park, as well as an ethnobotanical survey, aimed at identifying the GR as potential base for an ABS project.

Materials And Methods

Study area

The LNP, established in 2001, is part of the Great Limpopo Transfrontier Park (GLTP), which also includes Kruger National Park, in South Africa, and Gonarezhou National Park, in Zimbabwe [24]. This Transfrontier Park is part of a wider conservation programme and is the heart of the Great Limpopo Transfrontier Conservation Area, an area that was set up to encourage the formation of alliances among different stakeholders, and as a tool to promote sustainable land use, biodiversity conservation and poverty alleviation in rural areas [31]. The LNP extends from the western side of the Mozambican section of the Limpopo river to the border with South Africa. To the south, the Park is bordered by the Olifant River [14], one of the main tributaries of the lower Limpopo, which plunges there after the Massingir Lake [7].

Inside the Park, a territory of around 10.000 Km^2, live more than 35.000 people. Most of them are clustered in 44 villages, located within the buffer zone, which is administratively considered as an integral part of the Park, while a small part of population still lives along the banks of the Shingwedzi River, i.e. within the core area of the Park [14].

The field research was carried out in the Massingir District, in the northern part of the Gaza Province (MZ). Five main sites were surveyed: four villages within the LNP (Madingane, Machaule, Chibotane and Mavodze) and the urban area of Massingir, immediately outside the Park (*Fig. 1*).

Figure 1*. Study area. The GLTP and its geographical position (on the left) and the survey sites (on the right). Maps created with QGIS software*

The economy of the District is mainly based on agriculture, livestock, fishing, and tourism. However, the primary source of livelihood of the District is agriculture with around 80% of the population living from agricultural activities, mainly practiced by family producers organized in associations [25]. Livestock farming includes breeding cattle, goats, poultry and, to a lesser extent, pigs, while the crop production is based on maize, cowpeas, groundnuts, potatoes, watermelons, and pumpkins. Also oranges are produced so as a small amount of vegetables [13].

Although most of the population is engaged in agriculture, its productive potential is not fully tapped in the District, mainly because of rudimental production methods, lack of technical knowledge, the absence of an adequate network of services, and irregular rainfall [25]. Furthermore, the local wildlife has a notable impact on agricultural production. *Human-wildlife conflicts* (HWC), mainly in the form of damage to crops, occurs frequently because of the coexistence of human and wildlife communities [12]. This phenomenon is common across the Country, with the Gaza province emerging as one of the most affected, particularly by elephants (*Loxodonta africana*) [20]. Within the Park, the area belonging to the Massingir District is the most implicated in this problem. According to data collected by the LNP between 2007 and 2010, three-quarter of the HWC

incidents within the Park occurred in the District's area with most of them involving damage to crops by elephants and hippopotamuses (*Hippopotamus amphibius*) [23]. The mitigation of HWC has been one of the reasons why the authorities have justified the resettlement programme for people who live in the Shingwedzi River Valley [24]. As can be inferred by the "Resettlement Action Plan for Macavane village", relocation has been adopted as the main solution to deal with the growing HWC, while promoting the development of tourism and the conservation of wildlife, consistently with the identification of the Shingwedzi River Valley as a primary area for these objectives [29]. Although the resettlement programme was presented as a development opportunity for residents [24], other resettlement programmes were associated to the high risk of further impoverishment [4]. Indeed, the residents of Shingwedzi Rivers Valley feel deprived of the natural resources they traditionally turned to for their livelihood [24].

The commercialization of products derived from agriculture, livestock breeding or fishing, is rendered difficult by the lack of adequate infrastructures. Indeed, the area is relatively isolated from the Country's commercial centres and the motorway network linking the main road to the villages is poor and frequently not accessible during the rainy season [13].

The climate of the District is dry semi-arid. Average annual temperature is about 30° C and annual rainfall is around 600 mm, with a potential evapotranspiration generally above 1.500 mm [25]. Two main season can be identified: a dry season, from April/May to October/November, with temperatures ranging from 14°C to 28°C and maximum precipitation of around 70 mm; and a hot and humid season, from October/November to April/May (spring-summer period), with temperatures ranging from 20°C to 33°C and maximum precipitation of 370 mm [33].

The vegetation of the study area is included in the Zambezian phytogeographical region and is dominated by the Mopane forest (*Colophospermum mopane*) [16; 27] with monzo (*Combretum imberbe*) and mecrusse (*Androstachys johnsonii*) [25]. Around 15 plant communities have been described in the arid inland areas of the Gaza province. There are similarities between the landscapes of the LNP and those of the Kruger National Park. The main difference is the larger percentage of sandy landscapes of LNP, which make up 44% of its surface. The typical landscapes near the survey sites are *Salvadora angustifolia* floodplains, *Colophospermum mopane* shrubveld on calcrete, and the "Massingir Velho Sandveld" (*Terminalia sericea – Eragrostis pallens* and *Combretum apiculatum – Pogonarthria squarrosa* low woodlands, with patches of *Colophospermum mopane – Panicum maximum* short woodland) [35].

The socio-economic situation of the Park's ILCs

In order to identify an ILC that could be involved in an ABS project a socio-economic survey of the Changana community was conducted, which included gathering information about the population's living conditions. 500 questionnaires were distributed between June and September 2016, with the contribution of two local officers: the village chief of Mavodze (for the questionnaires distribution in the villages inside the Park) and Mr Antonio Jorge (for data collection in Massingir town). Their contribution was fundamental for translating the questionnaires from English to the local idiom (*Shangana*) and for overcoming other linguistic differences. The questionnaires of self-compiled type, with individual target and tied return, inquired about the level of education, the employment situation, housing condition, methods for the supply water, and the sources of energy. Interviewees were randomly selected.

List of plants species used by ILCs

In order to identify the GR for a potential ABS project, an ethnobotanical research was conducted in two phases. In the first phase, from June 2016 to August 2018, the 53 species and associated TK of Ribeiro et al. [33] ethnobotanical research were used as a preliminary list. Such list was expanded with species commonly used by the Changana community as a food or energy resource, for producing manufacts, and in traditional medicine. For the selection of these species we used the contribution of local people, who indicated the vernacular names and the TK associated with them. The second phase (August 2018 – November 2018) entailed a refinement of the plant list, which also included the elimination of non-native species, identified through the reference online portals "Plants of the World online" (32) and "Global Biodiversity Information Facility" (15). Such an approach has been adopted for consistency with the biodiversity focussed programme SECOSUD II the present work is part of. In order to identify possible endemisms, the geographical distribution ranges of the species were investigated

through the above databases. We considered as endemic species only occurring within the Mozambique's borders. In turn, as to the "near-endemic" category, considering its lack of a generally accepted definition [11], the criterium we adopted included the following assumptions: 1) the species is globally known from five or fewer localities; 2) the range of the species only extends to countries bordering Mozambique.

Results

The socio-economic situation of the Park's ILCs

With around 90% of the questionnaires returned, the selection of operators and the adopted survey techniques can be considered appropriate. The most frequent age groups are "young" and "adults" (35% and 37,2% of respondents respectively). Also "young adult" age group is well represented, with a 26,3% of respondents, while the "over 60" participation is low, with a 1,5% of respondents. No differences in respondents ratio can be attributed to gender partitioning.

Respondents are generally low educated, with a 43,6% illiterate and only 31,2% speaking Portuguese, in addition to the "Shangana" language.

The notable identified unemployment rate (with a 41% of respondents) is relatively higher within the Park (49%) than in Massingir town (31%).

The data on the adopted housing solutions (*Fig. 2*) provide a good reflection of the socio-economic situation, with up to 68% of respondents living in "palhota" (local name indicating rudimentary huts). Only 8% lives in conventional houses (single-family housing units, built with durable materials), while the remaining 24% adopts other types of housing solutions, which include: apartments, mixed houses (partly built with durable material and partly with plant material), "comboio" (shared room), common houses (single family housing units, built with durable materials), and temporary houses. When comparing Massingir to villages inside the park, the presence of conventional houses within the town (15,4%) is significantly higher than in the villages (1,2%); conversely palhota, which represent 77,3% of the homes of village respondents, fell to 56,7% in the urban area.

***Figure 2**. Housing solutions adopted in Massingir town and in the villages inside the Park*

As to the energy supplies, 100% of respondents relies on firewood for housing services (cooking, heating, lighting), while only 4% has electricity at home, which are all concentrated in Massingir town.

Finally, as to water supply (*Fig. 3*), only 2% of respondents has running water directly inside the house, while around 20% relies on water stored in tanks. 45% of the respondents relies on manual boreholes and hand pumps, while 32% relies on natural water sources as rivers, streams, and ponds.

When comparing the villages to Massingir town, running water is exclusively present in the latter. 5,5% of the Massingir respondents has access to running water, whereas the majority of them rely on hand-pumps (50,7%), less on manual boreholes (20,4%) or stored water supply (21,4%). Only 2% of the interviewees of the town relies on natural water sources. In the villages, around 57% of respondents depends on natural water sources, while 24,3% adopts water pumping systems. The remaining 18,6% of the population interviewed inside the Park relies on water supplies stored in tanks.

***Figure 3**. Water supply in Massingir town and in the villages inside the Park*

List of plants used by ILCs

The ethnobotanical survey has led to a list of 101 plants species (*Tab. 1*) potentially suitable for ABS projects. Scientific name, including family, vernacular name, growth form, type of use by ILCs and utilized parts are reported.

***Table 1**. List of 101 plants species used by local communities. Growth form was retrieved by the "Plants of the World online" or scientific publications, indicated by respective References' number*

Family	Species	Changana name	Changana use	Utilized part/s	Growth form
Achantaceae	*Blepharis diversispina*	Nchachacha wa mananga	Medicine	Roots, Leaves Bark, Resin	Shrub, Herb [22, 30, 33]
Alismataceae	*Limnophyton obtusifolium*	Not Available (NA)	Medicine, Cosmetic	Leaves, Resin, Roots	Herb [32]
Aloaceae	*Aloe marlothii*	Mhanga, manghani	Medicine, Food, Cosmetic	Roots, Flowers, Leaves, Resin	Shrub, Herb [30, 33]
Aloaceae	*Aloe zebrina*	Ximhangani	Medicine	Leaves, Roots	Herb [30]
Amaranthaceae	*Hermbstaedtia odorata*	Ntxomeli, Chomeli	Medicine, Beliefs (local beliefs or mystical rituals)	Flowers, Leaves, Roots	Herb [32]
Amaryllidaceae	*Crinum stuhlmannii*	Khonwua	Medicine, Veterinary	Roots	Herb [33]
Anacardiaceae	*Ozoroa engleri*	Xinungumafi	Medicine	Leaves, Roots, Bark	Shrub, Tree [32]
Anacardiaceae	*Ozoroa obovata*	Xinungu, himungumango, chinungo, chinungumafe	Medicine, Veterinary	Bark, Roots	Shrub, Tree [32]
Anacardiaceae	*Sclerocarya birrea* subsp. *caffra*	Nkany	Medicine, Food, Handicraft, Beliefs	Roots, Leaves, Fruits, Seeds, Structural parts, Bark	Tree [9, 33, 34]
Annonaceae	*Annona senegalensis*	Lonfa, Yembe	Medicine, Food	Fruits, Leaves, Bark, Roots, Flowers	Shrub, Tree [9, 22]
Apocynaceae	*Adenium multiflorum*	Chimua	Medicine, Beliefs	Leaves, Bark, Roots, Structural parts	Shrub, Tree [32]
Apocynaceae	*Carissa edulis* syn: *C. spinarum*	Mphewani	Medicine, Veterinary, Food	Roots, Fruits, Leaves	Shrub, Tree [9, 30]
Apocynaceae	*Pergularia daemia*	Tamoni	Medicine	Leaves, Resin, Flowers	Herb [32]
Apocynaceae	*Sarcostemma viminale* syn: *Cynanchum viminale*	Neta	Medicine, Veterinary, Food	Resin, Fruits, Roots, Structural parts	Herb [33]
Apocynaceae	*Secamone parvifolia* syn: *S. schweinfurthii*	Nyokani	Medicine	Roots	Shrub [33]
Araceae	*Stylochiton natalensis*	NA	Medicine, Beliefs	Roots	Herb [32]
Arecaceae	*Hyphaene natalensis* syn: *H. coriacea*	Nala	Food, Handicraft, Beliefs	Structural parts, Fruits, Resin, Leaves	Tree [32]

Asparagaceae	*Asparagus africanus*	Kwangwa la tilo	Medicine, Cosmetic, Food, Beliefs	Roots, Fruits, Structural parts, Seeds, Leaves, Bark	Shrub [33]
Balanitaceae	*Balanites maughamii*	Nulu	Medicine, Handicraft, Beliefs	Structural parts, Roots	Tree [33]
Bombacaceae	*Adansonia digitata*	Ximuvo, Ximuwa	Medicine, Food, Beliefs, Handicraft, Fuel	Roots, Seeds, Fruits, Flowers, Bark, Structural parts	Tree [30, 33]
Burseraceae	*Commiphora africana*	Ndzapu	Medicine, Food	Roots, Bark, Leaves, Fruits, Resin	Shrub, Tree [32]
Canellaceae	*Warburgia salutaris*	Chibaha	Medicine, Food	Leaves, Fruits, Roots, Bark	Shrub, Tree [32]
Capparaceae	*Boscia albitrunca*	Nxukutsu	Medicine, Veterinary, Food, Handicraft, Beliefs	Leaves, Roots, Fruits, Structural parts, Bark	Shrub, Tree [33, 34]
Capparaceae	*Maerua edulis*	Xikolwa	Medicine, Food	Fruits, Leaves, Roots	Shrub [33]
Capparaceae	*Maerua parvifolia*	Nongonoko	Medicine, Food	Fruits, Leaves, Roots	Shrub [33]
Capperaceae	*Boscia mossambicensis*	Chimapamapane	Medicine, Food	Bark	Shrub, Tree [32]
Capperaceae	*Cadaba natalensis*	Tssatssassana, mejacocone	Medicine	Roots, Structural parts	Shrub [32]
Capperaceae	*Capparis tomentosa*	Wungwa, Caua, cahu, muodaball	Medicine, Beliefs	Roots, Leaves	Shrub, Tree [32]
Capperaceae	*Cladostemon kirkii*	Tumangoma, mahuco, buguane, tambocolata	Medicine, Beliefs, Cosmetic	Roots, Structural parts, Resin, Leaves	Shrub, Tree [32]
Capperaceae	*Thilachium africanum*	Compfa, compha	Medicine, Food	Roots, Bark	Shrub, Tree [32]
Celastraceae	*Elaeodendron schlechterianum* syn: *Cassine schlechteriana*	Chigugutze, Chigugutzo	Medicine, Food, Handicraft, Cosmetic, Fuel, Beliefs	Roots, Leaves, Bark, Structural parts, Fruits	Shrub, Tree [32]
Celastraceae	*Gymnosporia buxifolia*	Xihlangwa	Medicine, Veterinary, Handicraft, Beliefs	Bark, Leaves, Roots, Structural parts	Shrub [32]
Celastraceae	*Loeseneriella crenata*	Lorho, nhlohlo	Medicine	Roots	Shrub [33]
Celastraceae	*Maytenus senegalensis* syn: *Gymnosporia senegalensis*	Chilhangua	Medicine	Leaves, Bark, Roots	Shrub, Tree [32]
Clusiaceae	*Garcinia livingstonei*	Mbimbi	Medicine, Food	Fruits, Roots, Bark, Seeds	Tree [32]
Combretaceae	*Combretum apiculatum*	Xikhavi, chivonzôane, samabulile	Medicine	Seeds, Bark, Leaves, Roots	Tree [32]
Combretaceae	*Combretum imberbe*	Monzou	Medicine, Beliefs	Roots, Leaves, Flowers, Bark	Shrub, Tree [33]

Combretaceae	*Combretum microphyllum*	Funté	Medicine, Beliefs	Roots, Flowers	Shrub [32]
Combretaceae	*Combretum molle*	Xikukutsi	Medicine, Beliefs,	Roots, Leaves, Bark	Tree [32]
Combretaceae	*Combretum mossambicense*	Fute	Medicine	Roots, Bark	Shrub, Tree [32]
Combretaceae	*Combretum paniculatum*	Xikola, xikolve	Medicine, Beliefs	Roots	Shrub [32]
Combretaceae	*Combretum zeyheri*	Nthole	Medicine	Roots, Bark, Leaves	Shrub, Tree [32]
Combretaceae	*Pteleopsis myrtifolia* syn: *Terminalia myrtifolia*	Ludzane	Medicine, Food, Beliefs	Leaves, Roots, Fruits	Shrub, Tree [32]
Combretaceae	*Terminalia sericea*	Nsunsu, nkonola, kondla, konola	Medicine	Bark, Roots	Shrub [9, 30, 33]
Cordiaceae	*Cordia ovalis* syn: *Cordia monoica*	Mponwane	Medicine, Veterinary, Food	Leaves, Fruits, Seeds, Roots, Bark	Shrub, Tree [32]
Cucurbitaceae	*Cucumis metuliferus*	Dema	Medicine	Roots	Herb [33]
Cucurbitaceae	*Cucumis zeyheri*	Xiyaka yakane, xihakahani	Medicine, Food	Leaves, Fruits	Herb [33]
Dracenaceae	*Sansevieria hyacinthoides* syn: *Dracaena hyacinthoides*	Xikwenga xa kwhati	Medicine	Roots	Herb [33, 34]
Ebenaceae	*Euclea divinorum*	Kuangula, Klangula	Medicine, Food, Handicraft, Beliefs, Fuel, Cosmetic	Structural parts, Bark, Roots, Fruits, Leaves	Tree [22]
Ebenaceae	*Euclea racemosa*	Mulala	Medicine, Cosmetic	Roots, Leaves	Shrub [33]
Ebeneceae	*Diospyros mespiliformis*	Mphari, mgula, ntoma	Medicine, Food	Fruits, Leaves, Bark, Roots	Tree [22]
Euphorbiaceae	*Acalypha indica*	Ntlambissane	Medicine	Leaves	Herb [33]
Euphorbiaceae	*Androstachys johnsonii*	Cimbiri	Medicine, Beliefs, Handicraft	Roots, Structural parts	Tree [33]
Euphorbiaceae	*Euphorbia cooperi*	Ximintua mintuane	Beliefs	Leaves	Shrub, Tree [32]
Euphorbiaceae	*Flueggea virosa*	Nsangasi	Medicine, Food	Fruits, Roots	Shrub [30, 33]
Euphorbiaceae	*Jatropha zeyheri*	Mthewe	Medicine, Beliefs, Veterinary	Roots	Herb [30]
Euphorbiaceae	*Spirostachys africana*	Xilangamahlo	Medicine	Bark, Resin	Tree [33]
Euphorbiaceae	*Synadenium cupulare* syn: *Euphorbia cupularis*	Mdheve	Medicine, Cosmetic, Beliefs, Veterinary	Sap, Roots, Bark, Leaves	Shrub [32]

Fabaceae	*Cassia abbreviata*	Lumanyama	Medicine	Bark, Leaves, Roots	Shrub, Tree [30, 33]
Fabaceae	*Colophospermum mopane*	Gungwa shanazi	Medicine, Food, Handicraft	Roots, Leaves, Structural parts	Shrub, Tree [33]
Fabaceae	*Dalbergia melanoxylon*	Xipaladze, xipalatzi	Medicine, Beliefs	Roots, Leaves	Shrub, Tree [33]
Fabaceae	*Elephantorrhiza elephantina*	Xivurayi	Medicine, Food, Beliefs	Roots, Seeds Leaves, Structural parts	Shrub, Herb [30, 33]
Fabaceae	*Guibourtia conjugata*	Ntsotso	Medicine, Veterinary	Resin, Roots, Leaves	Tree [33]
Fabaceae	*Peltophorum africanum*	Txuva	Medicine, Food, Handicraft, Fuel	Roots, Leaves Structural parts, Bark, Flowers	Tree [9, 30, 33]
Fabaceae	*Pterocarpus angolensis*	Miyatahu	Medicine	Bark, Roots, Seeds	Tree [9]
Fabaceae	*Senegalia nigrescens*	Nkaye	Medicine, Beliefs	Roots, Leaves	Tree [32]
Fabaceae	*Senna petersiana*	Nembenembe	Medicine, Food, Beliefs	Roots, Seeds, Fruits, Leaves	Shrub, Tree [32]
Hypoxidaceae	*Hypoxis hemerocallidea*	Xirangabwana	Medicine	Leaves, Flowers, Roots	Herb [30, 34]
Malpighiaceae	*Acridocarpus natalitius*	Mabope, Mpetso	Medicine	Roots, Flowers, Leaves	Shrub, Tree [32]
Malvaceae	*Hibiscus meyeri*	Kongowa, Kloklonya	Medicine	Leaves, Flowers, Roots	Herb [33]
Meliaceae	*Trichilia emetica*	Nkuhlu	Medicine, Food	Leaves, Fruits, Seeds, Sap	Tree [33]
Menispermaceae	*Tinospora caffra* syn: *Hyalosepalum caffrum*	Nhokany ya yikulu	Medicine	Leaves, Roots	Shrub [32]
Moraceae	*Ficus capensis* syn: *F. sur*	Nkuwa	Medicine	Leaves	Tree [9]
Moraceae	*Ficus sycomorus*	Nkuwa	Medicine, Food, Fuel, Veterinary	Fruits, Structural parts, Bark, Resin, Sap, Roots	Tree [33]
Moraceae	*Maclura africana*	Nxloxlho, Tsumbula	Medicine, Beliefs, Veterinary	Leaves	Shrub, Tree [32]
Ochnaceae	*Brackenridgea zanguebarica*	Thavatsindi, Mthavatsindi	Medicine, Beliefs	Bark, Roots	Tree [9]
Olacaceae	*Olax dissitiflora*	Nandzamuntane namuntane	Medicine, Food	Fruits, Roots, Leaves	Shrub, Tree [33]
Olacaceae	*Ximenia americana*	Ntsengele	Medicine, Food, Beliefs	Roots, Fruits	Shrub, Tree [9, 30, 33]
Olacaceae	*Ximenia caffra*	Ntsenguele	Medicine, Food, Beliefs	Roots, Fruits, Leaves, Seeds	Tree [30]

Orchidaceae	*Ansellia africana*	Phakama	Medicine, Beliefs	Leaves, Structural parts, Bark, Roots	Herb (Epiphyte) [33]
Pedaliaceae	*Dicerocaryum eriocarpum* syn: *Sesamum eriocarpum*	NA	Medicine, Veterinary	Roots, Seeds, Flowers, Leaves	Herb [9]
Phyllanthaceae	*Pseudolachnostylis maprouneifolia*	Xojowa	Medicine, Food	Fruits, Roots, Bark, Leaves	Tree [32]
Poaceae	*Cynodon dactylon*	Rintlhangi, rithange	Medicine	Roots, Leaves	Herb [30, 33]
Ptarerolxylaceae	*Ptaeroxylon obliquum*	Ndzari	Medicine	Roots	Shrub, Tree [33]
Rhamnaceae	*Ziziphus mucronata*	Ndori, nceceny	Medicine, Food	Fruits, Leaves, Roots, Bark	Tree [22]
Rubiaceae	*Gardenia volkensii*	Xitsalala	Medicine	Roots	Shrub, Tree [30, 33]
Rubiaceae	*Vangueria infausta*	Mpfilwa	Medicine, Food	Fruits, Seeds, Roots	Tree [9, 30]
Rutaceae	*Zanthoxylum humile*	Manungwani	Medicine	Roots	Shrub, Tree [33, 34]
Salvadoraceae	*Salvadora persica*	Mpokwe	Medicine, Food	Roots, Leaves, Fruits	Shrub, Tree [32]
Sapindaceae	*Pappea capensis*	Mponda, Guvazwivi	Medicine, Food, Cosmetic	Fruits, Seeds, Leaves, Roots	Shrub, Tree [32]
Sapotaceae	*Manilkara mochisia*	Mwamba	Medicine, Food	Roots, Fruits	Shrub, Tree [33]
Solanaceae	*Solanum lichtensteinii*	NA	Medicine	Fruits, Roots, Leaves	Shrub [32]
Sterculiaceae	*Dombeya rotundifolia*	Xiluvari	Medicine, Food, Handicraft, Beliefs	Fruits, Flowers, Roots, Bark Structural parts	Shrub, Tree [32]
Sterculiaceae	*Hermannia micropetala*	Sindzambita	Medicine	Roots	Shrub [30]
Strychnaceae	*Strychnos madagascariensis*	Nkwankwa	Medicine, Food	Roots, Fruits	Shrub, Tree [30, 33]
Strychnaceae	*Strychnos spinosa*	Masala, Massala	Medicine, Food, Beliefs	Roots, Fruits, Leaves	Tre [22]
Tiliaceae	*Grewia flavescens*	Nsihane	Food, Beliefs	Fruits, Roots	Shrub [33]
Tiliaceae	*Grewia hexamita*	Nsihane	Food, Beliefs	Fruits, Roots, Leaves	Shrub, Tree [32]
Tiliaceae	*Grewia monticola*	Nsihane	Food, Handicraft	Fruits, Structural parts	Shrub, Tree [33]
Vitaceae	*Cissus cornifolia*	Mphesani	Medicine, Food	Fruits, Roots	Shrub, Tree [33]
Vitaceae	*Cissus quadrangularis*	Tchovoloti, Chovoloti	Medicine, Veterinary	Structural parts, Roots	Succulent [30, 33]

All the species in the list are native to Mozambique, with the exceptions of *Sarcostemma viminale, Jatropha zeyheri* and *Dicerocaryum eriocarpum*, which have been included being native to the Limpopo Basin area. No species is endemic to Mozambique. More than half (57) of the included species have a distribution limited to Southern and South-eastern Africa, fifteen of which can be considered as “near-endemic” for the Country: *Aloe marlothii*, *Ozoroa engleri, Adenium multiflorum, Stylochiton natalensis, Balanites maughamii, Warburgia salutaris, Cadaba natalensis, Androstachys johnsonii, Euphorbia cooperi, Jatropha zeyheri, Synadenium cupulare, Guibourtia conjugata, Acridocarpus angolensis, Hermannia micropetala* and *Grewia hexamita*.

The general framework on the local use of plants which emerged from the ethnobotanical survey is shown in *Fig. 4.* Most of the identified plants are used for medicinal purposes: about 94% of the species is used in treatments or remedies for various pathologies (classified under “medicine” in *Tab.1*). Around 14% of the species is used for livestock care (“veterinary”), especially for goats and cattle. An extensive use of the species is directed to “food”: 44,1% of the species is used for the preparation of food and drinks or as a subsistence resource. 8,8% of the species is used for personal care (“cosmetic”). Around 13% of the species is used to produce various types of tools, including fences or parts of housing (“handicraft”). Only 4,9% of the species is used as “fuel”. Finally, a significant 35% or so of the species is associated to local beliefs or mystical rituals (“beliefs”).

Four plants species are associated to the greatest variety of use: *Adansonia digitata*, *Boscia albitrunca* (5 different uses), *Elaeodendron schlechterianum* and *Euclea divinorum* (6 different uses). The species that have the greatest number of parts exploited, are 3: *Adansonia digitata,Asparagus africanus* and *Sclerocarya birrea*. For all these three species, 6 parts are used in various sectors.

Figure 4*. Differences in plant uses by the Changana community*

Medicinal use

The bulk of the diseases indicated by the WHO [42] as those with highest incidence of mortality and morbidity in Mozambique are traditionally treated through the species included in the list (malaria, tuberculosis, respiratory infection, dysentery, but not HIV nor meningitis).

Twelve species are used as a treatment for malaria or for alleviating its symptoms: *Carissa edulis*, *Cassia abbreviata*, *Colophospermum mopane*, *Commiphora africana, Pterocarpus angolensis,Warburgia salutaris* and *Senna petersiana* as a treatment; *Blepharis diversispina*, *Combretum apiculatum*, *Sansevieria hyacinthoides* and *Ximenia caffra* only to relive its symptoms; *Trichilia emetica* as a preventive of the disease.

Forty species are used for the treatment of intestinal disorders, particularly dysentery (their most dangerous and acute manifestation). Thirteen species are used by local healers for alleviating symptoms or as a treatment for the latter: *Adenium multiflorum*, *Annona senegalensis*, *Ansellia africana*, *Carissa edulis*, *Combretum molle*, *Combretum zeyheri*, *Cordia ovalis*, *Cucumis zeyheri*, *Diospyros mespiliformis*, *Peltophorum africanum*, *Pseudolachnostylis maprouneifolia*, *Pteleopsis myrtifolia* and *Ximenia caffra*.

Twenty-two species are used for treating respiratory diseases. Of these: *Annona senegalensis*, *Blepharis diversispina* and *Cadaba natalensis* for pulmonary infections; *Annona senegalensis, Cassia abbreviata, Pseudolachnostylis maprouneifolia,Capparis tomentosa*, *Pergularia daemia* and *Pterocarpus angolensis* for treating pneumonia; while *Ansellia africana* and *Gymnosporia buxifolia* as a remedy for pulmonary hypertension and pleurisy, respectively.

Eight species are used in the treatment of tuberculosis: *Acridocarpus natalitius*, *Aloe marlothii*, *Aloe zebrina*, *Ansellia africana*, *Balanites maughamii*, *Cadaba natalensis*, *Pterocarpus angolensis* and *Strychnos madagascariensis*.

No species is used to treat patients with meningitis nor HIV.

A number of traditional medical uses additional to those for the disease indicated by the WHO, have also been recorded (*Tab. 2*).

***Table 2**. Traditional medical uses for diseases not associated to the highest mortality or morbidity in Mozambique.*

Medical uses	Species
Venereal diseases	Adansonia digitata, Aloe marlothii, Annona senegalensis, Asparagus africanus, Capparis tomentosa, Cassia abbreviata, Combretum apiculatum, Crinum stuhlmannii, Dalbergia melanoxylon, Diospyros mespiliformis, Euclea divinorum, Maerua edulis, Maytenus senegalensis, Pseudolachnostylis maprouneifolia, Pteleopsis myrtifolia, Pterocarpus angolensis, Sarcostemma viminale, Sclerocarya birrea, Secamone parvifolia, Terminalia sericea, Tinospora caffra
Fever and flu symptoms (cough/cold)	Acridocarpus natalitius, Adansonia digitate, Adenium multiflorum, Blepharis diversispina, Cassia abbreviate, Cissus quadrangularis, Combretum imberbe, Combretum molle, Combretum mossambicense, Combretum paniculatum, Combretum zeyheri, Commiphora africana, Diospyros mespiliformis, Dombeya rotundifolia, Elephantorrhiza elephantina, Euclea divinorum, Ficus sycomorus, Guibourtia conjugate, Gymnosporia buxifolia, Hypoxis hemerocallidea, Jatropha zeyheri, Maytenus senegalensis, Pergularia daemia, Pseudolachnostylis maprouneifolia, Salvadora persica, Sansevieria hyacinthoides, Senna petersiana, Solanum lichtensteinii, Strychnos spinosa, Warburgia salutaris, Ximenia caffra
Leprosy	Combretum apiculatum, Combretum imberbe, Combretum molle, Cordia ovalis
Cholera	Senna petersiana
Scabies	Elephantorrhiza elephantina, Hermbstaedtia odorata, Ozoroa engleri, Sclerocarya birrea, Strychnos spinosa
Different sorts of pain	Hibiscus meyeri
Verm infections	Maytenus senegalensis
Allergies	Blepharis diversispina, Maerua edulis, Synadenium cupulare, Vangueria infausta
Epilepsy	Tinospora caffra

Food use

Forty-five plant species are used for the preparation of beverages (tea, coffee, and beer or other alcoholic drinks) and meals (soups and porridge).

Around 82% of the species in the list provide fruits, which traditionally are the most utilized part of the plants. From 15,56% and 13,33% of the species seeds and roots are respectively used. Only from about 11% and 9% of the species leaves, and flowers and bark are respectively used. Finally, only from around 2% of the species resin and sap, and structural parts are extracted.

Some species represent an important source of nourishment for the Changana community: *Adansonia digitata, Asparagus africanus*, *Manilkara mochisia*, *Strychnos spinosa* which have fruits with a high nutritional value, and *Ziziphus mucronata* which offers very nutritious leaves. Similarly, *Ficus sycomorus* has very nutritious fruits, and represents an important source of food during dry seasons. Such species consumed for food as *Hyphaene natalensis*, *Maerua parvifolia*, *Olax dissitiflora,* and *Ximenia americana* are notable for the high vitamin content of their fruits. *Maerua edulis* and *Ximenia caffra* are also very important for the community as they are eaten by shepherds during grazing.

Cosmetic use

Nine plant species are used for personal care. In particular, *Aloe marlothii* and *Cladostemon kirkii* resin, *Asparagus africanus* leaves and *Pappea capensis* seeds are used for hair treatments. The branches with frayed end of *Elaeodendron schlechterianum* and *Euclea divinorum,* so as the roots of *Euclea racemosa,* are used for oral hygiene. The roots of *Limnophyton obtusifolium,* which are believed to have important cleansing and disinfectant properties, are used for cleaning infants. The sap of *Synadenium cupulare* is used to decorate the skin.

Discussion

The GR identified through our ethnobotanical survey could have an important commercial potential. Albeit the major number of traditionally utilized species is associated to the medical and the food sectors, also a few species are worth consideration in the cosmetic sector. The significant number of species traditionally used in the medicinal sector and in the food sector, corroborates the merit to set up research and development projects focusing on them, within the framework of ABS measures. This consideration is supported by previous ABS experiences, which led to agreements between ILCs and research centres, specifically related to the access to GR with medical potential. The articulated TK uses identified in our investigation can provide a useful refence case for further investigations on the commercial potential of Mozambique plant GR and their bearing on local the development of local communities. An effective follow up to our assessment of the potential viability of ABS projects in Mozambique could be a field survey aimed at evaluating the available stock of plants, and an accurate biochemical analysis for identifying the compounds and active ingredients of the species in the list with medical potential.

The socio-economical survey of Limpopo National Park's ILCs underscores the precariousness of the housing solutions in the area and highlights some criticalities in the living condition of these communities which depend on limited sources of livelihood and poor housing conditions, and face difficulties with water supply. The results of the present work appear overall consistent with the 2007 census, reported by Ministério da Administraçao Estatal [25], according to which rudimental mixed house (61,6%) and palhota (30,1%) are the most widespread housing solutions. Some comparative differences with our results could be explained by the significant inclusion in the census of urban areas data, whereas our investigation includes primarily rural areas. Similarly, also for water supply and the availability of electricity in homes, our results are in line with the 2007 census, confirming the access to basic services is extremely limited in the study area. Moreover, the recorded high unemployment rate indicates a significant dearth of economic income for the community. The lack of economic alternatives is more critical for the "poor" and "very poor" social classes, which occasionally resort to sale the extra livestock and alcoholic beverages and/or to undertake casual labour jobs. Also for "middle" and "better off" social classes, the sale of livestock is the first economic option. These classes are primarily engaged in small-scale trading activities, which is however limited by the conditions of their main costumers: the poorest social classes [13]. Finally, the socio-economic scenario of the Changana community is exacerbated by the effects of the relocation programme. For the above considerations, an ABS pilot project, set on plant species identified in this work, may represent an outlet for the economy development of the such community.

Furthermore, considering the conservation status and the limited geographical distributional range of a number of the species in the list, the design and implementation of an ABS project in the LNP could also contribute to biodiversity conservation. Indeed, the ABS provisions for the use of GR include aspects of natural resources management which contribute to the sustainable use of biological diversity and its conservation [8]. In this regard, links between the benefits derived from the utilization of GR and the conservation of biodiversity are evoked in the NP, which establishes the obligation to direct a part of the benefits arising from the use of GR towards the conservation of biological diversity [5]. Moving to our list, such sustainable management and conservation of GR elements could play a crucial role toward the preservation of three species: *Dalbergia melanoxylon, Ansellia africana* and *Warburgia salutaris*, which in The IUCN Red List of Threatened Species [19] are respectively classified as "near threatened" [41], "vulnerable" [10] and "endangered" [18].

Although our work supports the Mozambique eligibility for ABS projects, the current domestic policy needs to be revised. Mozambique adopted its ABS regulation in 2007, the *Regulation sobre Acesso e Partilha de Beneficios Provenientes de Recursos Genéticos e Conhecimento Tradicional Associado.* Such a Regulation aims to establish rules governing the access to, and the protection of GR and of the associated TK, to the conservation and sustainable use of biodiversity and, leading to fair and equitable sharing of benefit arising from their use [3]. Nevertheless, considering the recommendation of the Interim National Report of the Implementation of the Nagoya Protocol [37], the Regulation must be urgently revised to align with the intention of the NP and to achieve an efficient ABS regime.

Conclusion

The outcomes of the present work support the contention that Mozambique has a significant eligibility potential for Access and Benefit Sharing projects. Additionally, they can contribute to the identification of a possible ABS pilot project as a case study to support the evaluation of the policy efficacy and the implementation of the NP in the Country. In particular, our work shows the

potential of the LNP to support a pilot project which could lead to the conservation and sustainable use of local GR as well as contribute to the economic development of the relevant ILCs. With the above perspectives, the Country's ABS policy should be urgently revised to align with the provisions of the NP.

Abbreviations

ABS: Access and Benefit Sharing, CBD: Convention on Biological Diversity, CSIR: Council for Scientific and Industrial Research of South Africa, GLTP: Great Limpopo Transfrontier Park, GR: Genetic Resources, HWC: Human-Wildlife Conflict, ILCs: Indigenous and Local Communities, LNP: Limpopo National Park, NP: Nagoya Protocol, TK: Traditional Knowledge.

Declarations

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Authors' contributions

AG designed the research project. RV coordinated and carried out the data collection. FA, GT and LM provided a general contribution to the drafting of this manuscript. EN was the principal investigator. All authors read and approved the final manuscript.

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The overall data are available from the authors.

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Not applicable.

Consent for publication

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Competing interests

The authors declare that they have no competing interests.

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Figures

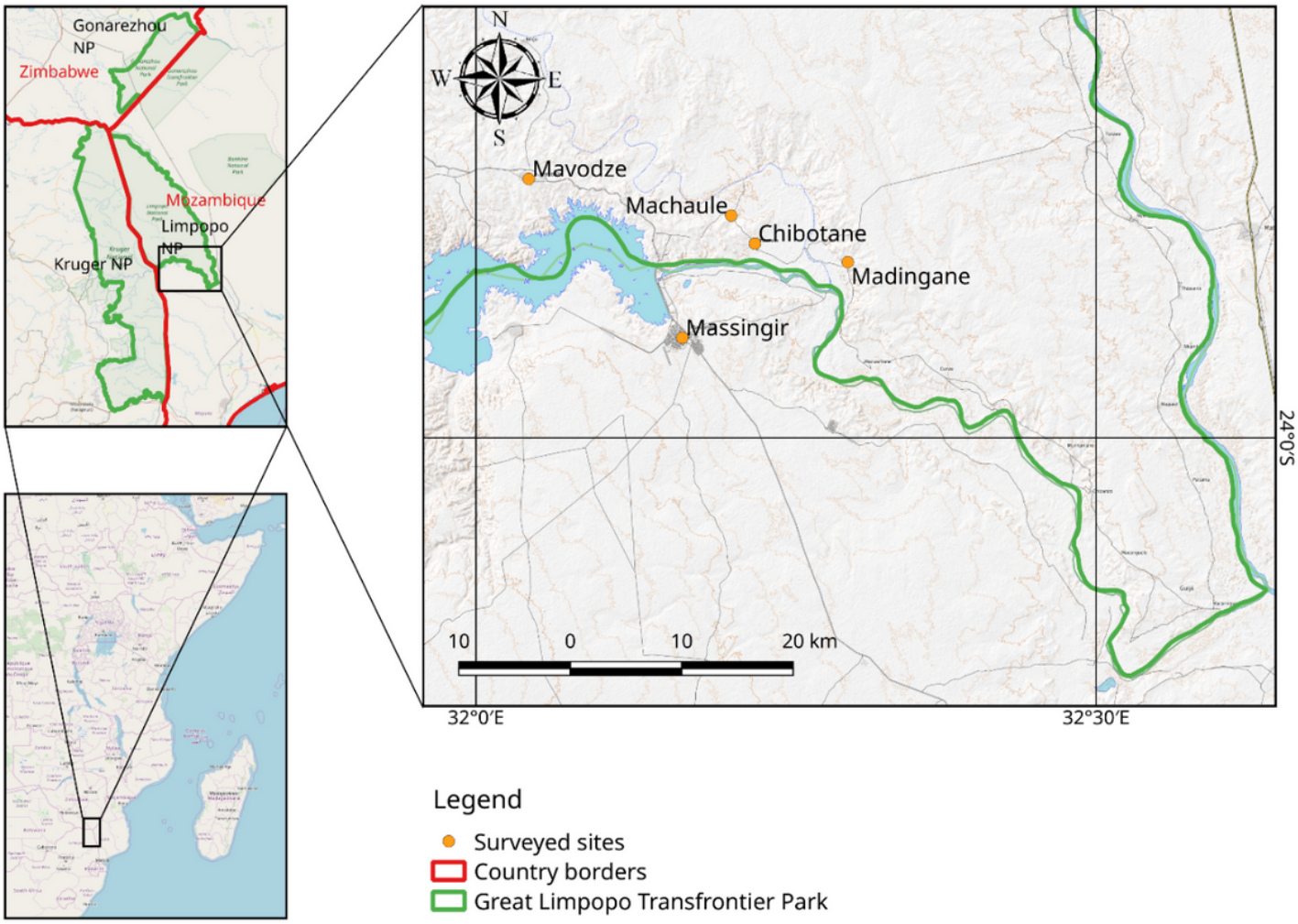

Figure 1

Study area. The GLTP and its geographical position (on the left) and the survey sites (on the right). Maps created with QGIS software

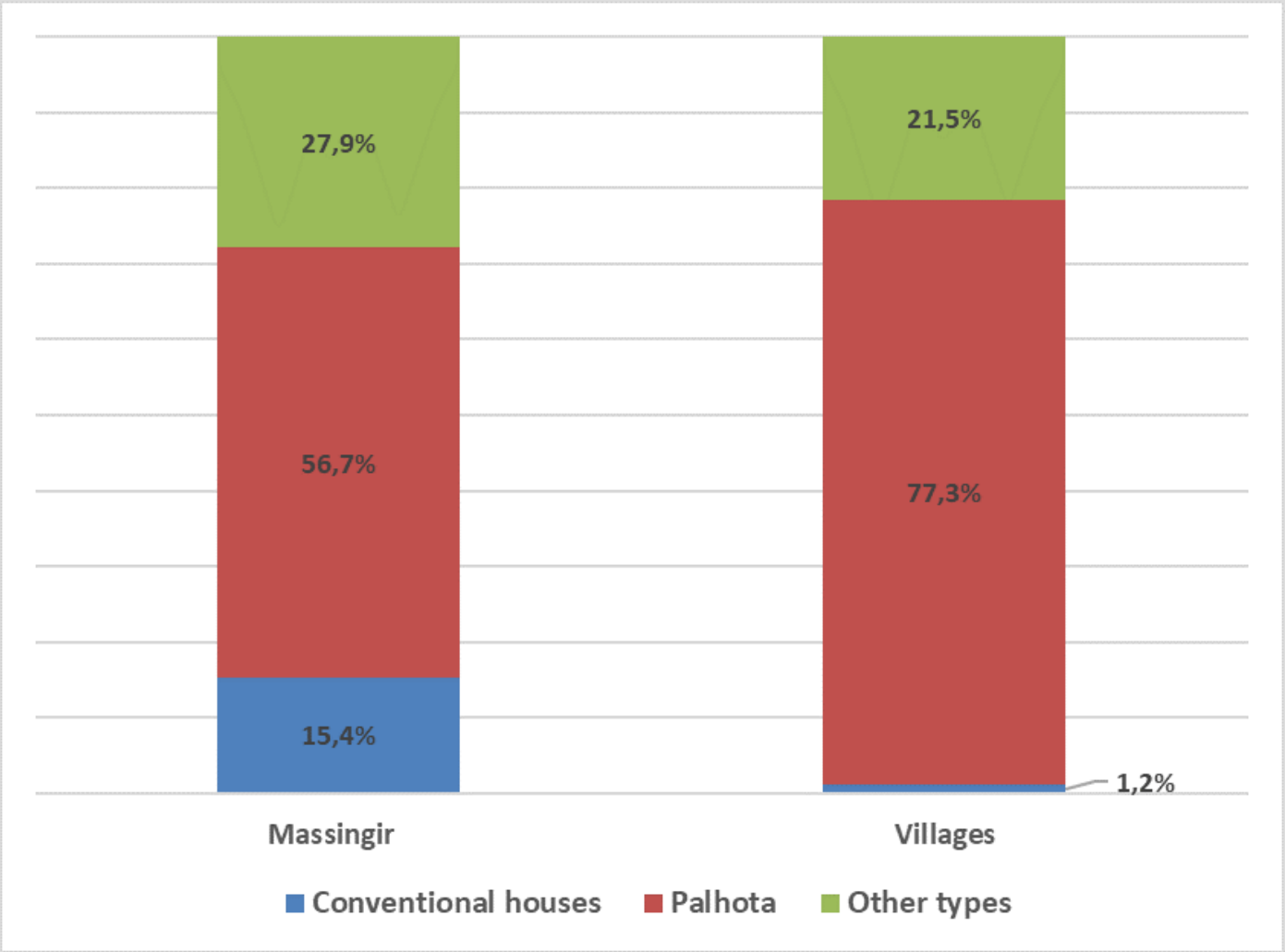

Figure 2

Housing solutions adopted in Massingir town and in the villages inside the Park

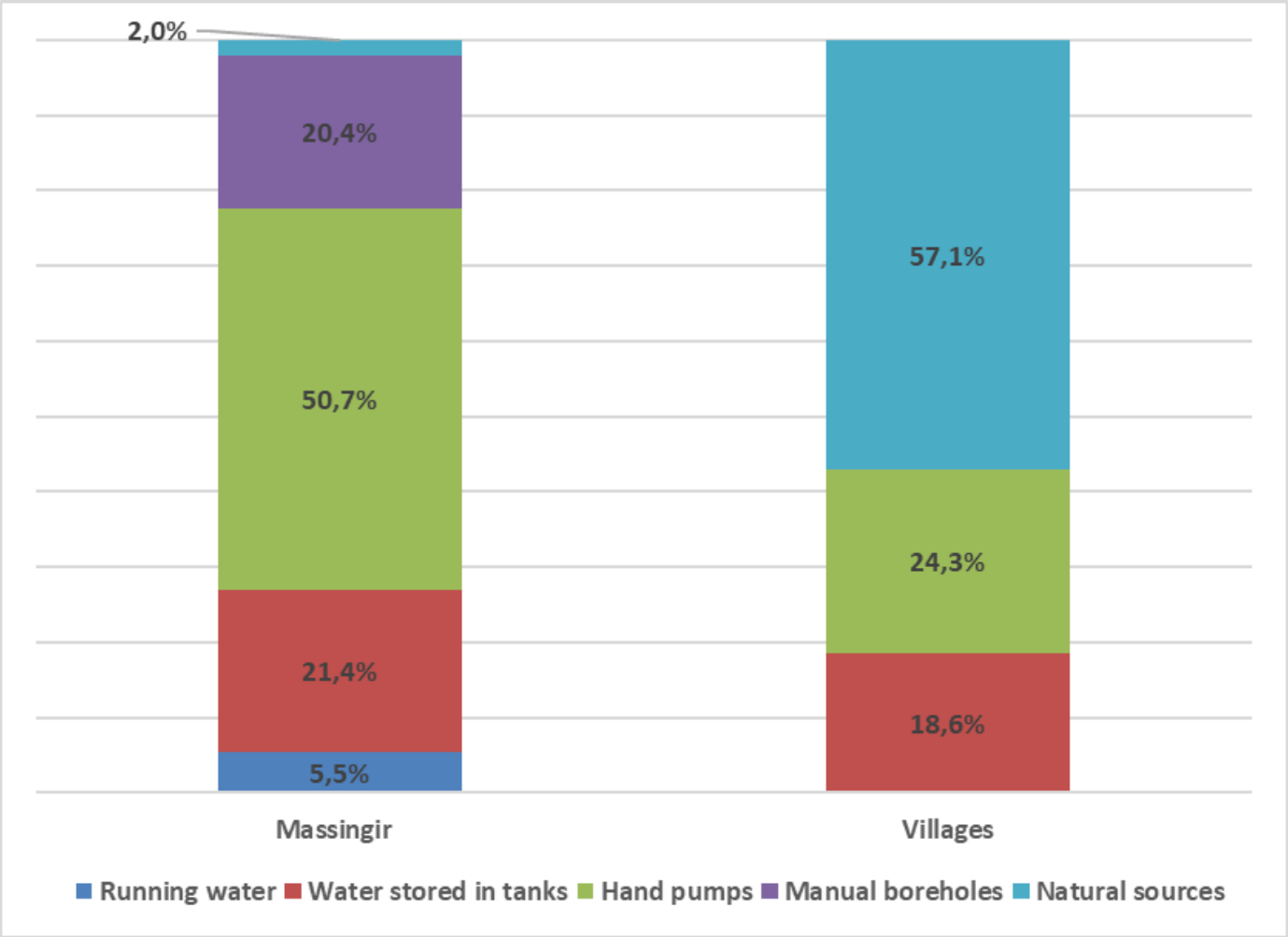

Figure 3

Water supply in Massingir town and in the villages inside the Park

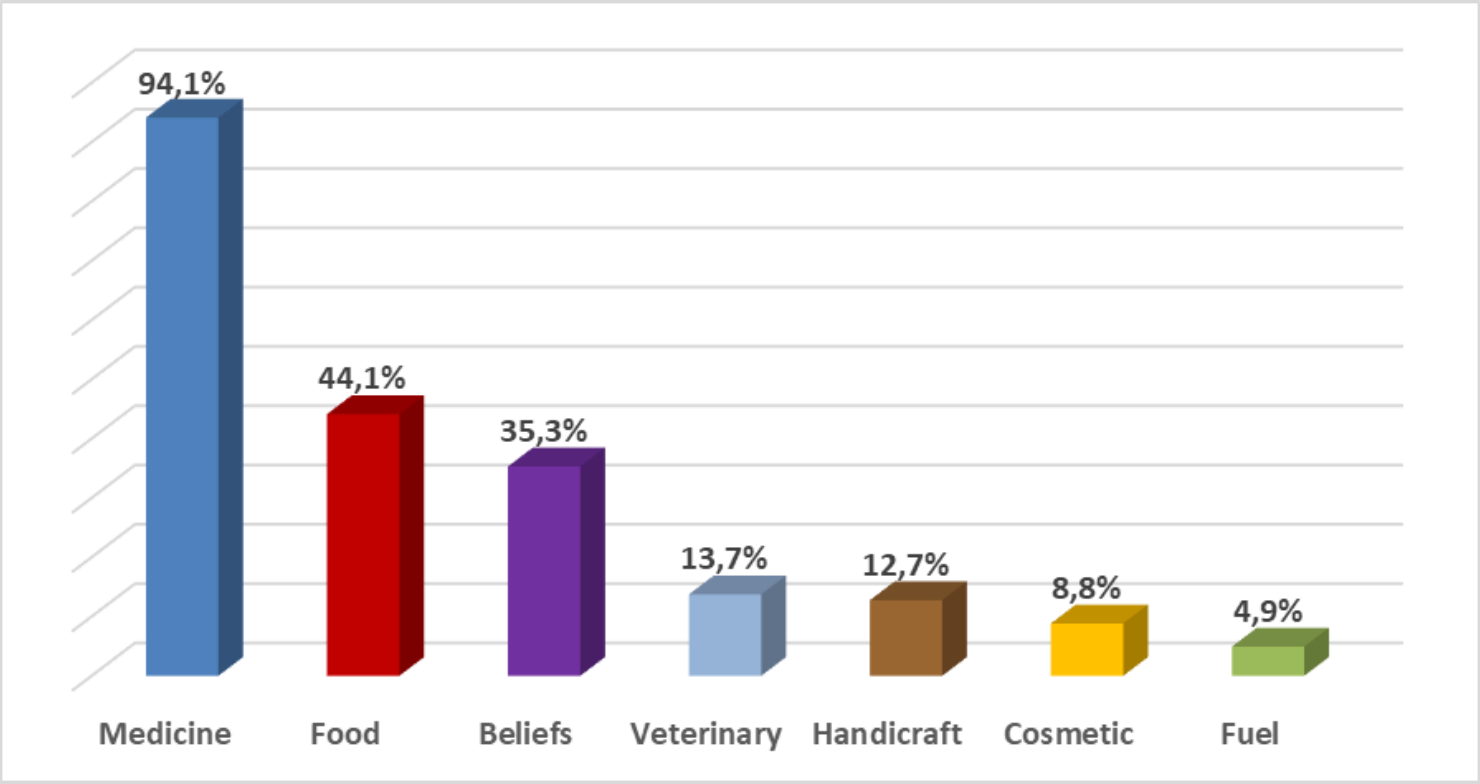

Figure 4

Differences in plant uses by the Changana community