Support to Project for the sustainable use of Non-Timber Forest Products in and around Gilé National Reserve, Mozambique

Mid-term report

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MArch 2020

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Resumo executivo

Desde 2007, a Fondation François Sommer/*International Foundation for Wildlife Management* (FFS-IGF) está a gerir a Reserva Nacional do Gilé em parceria com a Administração Nacional das Áreas de Conservação (ANAC), com o objetivo de conservar a biodiversidade faunística e florística, assim como acompanhar as comunidades circunvizinhas para prosperar dentro da nova conjuntura de conservação da zona.. Neste contexto, o Departamento de Desenvolvimento Comunitário (CDD) da Reserva está a liderar um projeto ambicioso para o desenvolvimento da cadeia de valor de diversos produtos florestais não madeireiros (*Non-Timber Forestry Products*, NTFPs) com potencial para promover atividades de geração de renda para as comunidades da zona tampão.

Um desses produtos é o cogumelo selvagem, além de ser apreciado nas comunidades que vivem ao redor da Reserva, apresenta um valor comercial tanto nos mercados locais quanto provinciais. A segunda causa deste interesse sob o cogumelo é que a colheita e o processamento são atividades tradicionalmente reservadas para as mulheres, o que constitui uma oportunidade para promover o empoderamento econômico feminino e o desenvolvimento social equilibrado.

No início do projeto NTPFs, o CDD concebeu a estratégia de desenvolvimento para a cadeia de valor do cogumelo na Reserva e na sua zona tampão. Vários grupos de mulheres estão a ser estruturados e acompanhados na aplicação de técnicas apropriadas de colheita e processamento, de maneira que a qualidade e a quantidade de produto processado sejam melhoradas, e assim garantir uma fonte de rendimento adicional para as comunidades. No processo de implementação desta estratégia, diversas questões surgem e precisam serem respondidas por fim de definir uma estratégia definitiva para um desenvolvimento sustentável da cadeia de valor adaptado ao contexto.

Através desta consultoria, a Nitidæ ambiciona apoiar o projeto NTPFs com a melhoria dos conhecimentos e a transferência de capacidades a longo prazo para a equipe da RNG, no âmbito dos esforços de monitoria e de desenvolvimento das técnicas de produção e transformação sustentáveis. Como primeiro passo, uma missão de terreno foi realizada por duas especialistas nas matérias de produtividade biológica e de processamento, respectivamente. Durante 10 dias, a Nitidæ trabalhou na zona tampão da RNG com os membros do CDD e conjuntamente com vários grupos de coletadoras de cogumelos, para observar as etapas de colheita e de processamento (secagem). O relatório das atividades realizadas é apresentado neste documento, assim como as reflexões e os resultados que surgiram durante a missão.

O trabalho que o CDD está a realizar nos grupos de colheita dos cogumelos é uma tarefa necessária para fazer um seguimento da colheita, melhorar o conhecimento e assegurar a sua gestão efetiva no futuro. É imprescindível ampliar o conhecimento actual sobre as espécies procuradas e de estabelecer os limites de produtividade biológica para determinar assim as quantidades máximas a serem coletadas para uma continuidade sustentável da actividade. Um protocolo de amostragem esta sendo adaptado da literatura científica e posto em prática com os técnicos do CDD para fazer o seguimento da produtividade dos cogumelos em parcelas seleccionadas aleatoriamente. As experiências de terreno e as discussões com a equipe do CDD provaram que as propostas feitas são acessíveis e simples de implementar na prática. A sua aplicação sobre o terreno, numa escala representativa ao longo de vários anos fornecerá uma estimação robusta do potencial de produção na RNG e sua zona tampão.

Uma grande quantidade de dados tem sido coletada por a equipe do CDD sobre a colheita, o consumo e a venda de cogumelos na zona. Esta etapa de procura de informação poderia ser facilitada, sistematizada e generalizada com a adopção de sistemas de colheita de dados baseados em tecnologias móveis abertas (como a suite ODK).

Também, na base de estudos prévios, a identificação de algumas espécies procuradas na missão de terreno tem sido confirmada. Este trabalho deveria ser continuado para determinar as principais espécies de interesse para as comunidades vizinhas da Reserva.

O trabalho com os grupos de coletoras de cogumelos está a dar resultados encorajadores. Durante a missão puderam constatar-se que as boas práticas de colheita introduzidas pelo CDD são seguidas na prática pelas mulheres dos grupos durante as colheitas.

Todas as etapas do processamento dos cogumelos foram observadas pois discutidas com as mulheres do grupo de Vassele, para compreender as razões das práticas delas e finalmente propor algumas modificações com tal de melhorar a qualidade do produto final. A etapa de secagem é aquela que precisa de um material mais desenvolvido. Várias configurações diferentes de secadores solares foram construídas com a ajuda da comunidade de Vassele e a equipe do CDD, pois testadas. Os resultados dos testes de secagem foram bons: 3 dias de secagem em comparação com 4 o 5 dias em caso de fazer um secagem tradicional. A humidade do produto final via-se aceitável nas primeiras experiências, contudo o secador deverá ainda ser melhorado para mais estabilidade do produto. O modelo é facilmente replicável, pois todos os materiais usados na construção estão disponíveis em Gilé e ele pode ser completamente fabricado por não profissionais na comunidade.

Outras considerações sobre as etapas prévias à secagem (limpeza, cozedura) poderiam ser objeto de reflexão com o fim de respeitar o processo estândar, e adaptar as etapas para um setor de mercado que poderia apreciar a qualidade do produto não cozinhado; e sensibilizar as comunidades que não é obrigatorio de ferver os cogumelos como é de costume nas comunidades. Contudo, as reflexões feitas são parciais e precisam de serem completadas com as conclusões do estudo de mercado em curso e a observação do processamento de diferentes espécies (até agora, só eyúkuli, ehí e khaduve puderam ser testados).

As mulheres do grupo de colheita de Vassele mostraram-se recetivas aos novos métodos, e apreciaram inovações no processamento como a secagem em pratos e o corte fino dos cogumelos frescos antes de enviar para secagem. Elas parecem compreender que o respeito das consignas de higiene é necessário para ter acesso a um mercado de gama alta, e estão motivadas para levar seu produto a um nível mais alto. Porém, as condições ainda não estão reunidas para garantir as mínimas condições higiénicas e de gestão do material.

A fim de continuar a reflexão sobre esses temas, a assistência técnica será fornecida a distância, também com respeito da eleição da embalagem; em relação com as conclusões do estudo de mercado em curso. Tal e qual acordado com a equipe, os seguintes documentos elaborados serão:

1. Uma nota com comentários sobre a estratégia de desenvolvimento da cadeia de valor Cogumelo

2. Um manual de processamento com desenhos/esquemas/fotos em português, incluindo as boas práticas de processamento
3. Um relatorio sobre a avaliação do potencial de comercialização dos cogumelos da Reserva.

Como recomendação geral para um trabalho de meio a longo prazo, indica-se a oportunidade de ligar a sustentabilidade da cadeia de valor do cogumelo à sustentabilidade meio-ambiental, através da pesquisa aplicada ao cultivo do cogumelo, e a promoção da preservação de zonas arvoradas na zona tampão para promover a produtividade dessas parcelas.

Table of contents

Glossary of terms 7
1_ Context 8
1.1. The Gilé National Reserve 8
1.2. The NTFPs project 8
2_ Field trip description 9
2.1. Objectives 9
2.2. Schedule 9
2.3. Location 10
3_ Edible mushrooms characterization 10
3.1. Information on some edible mushrooms 10
3.2. Implementation of a data collection system 14
4_ Biological productivity study 16
4.1. Objective 16
4.2. Methodology: 16
4.3. Protocol test 16
5_ Mushrooms harvesting practices 17
5.1. General information about harvesting 17
5.2. Good practices 18
6_ Mushroom processing 20
6.1. Traditional vs improved processing methods 20
6.1.1. Cleaning 20
6.1.2. Cooking 21
6.1.3. Slicing 21
6.1.4. Drying 22
6.1.5. Packing 23
6.1.6. Good processing practices 26
6.1.7. Conclusion on processing itinerary 26
6.2. Development of improved solar dryers 29
6.2.1. Available materials 29
6.2.2. Workforce 31
6.2.3. Drying during the night 32
7_ Conclusion 34

8_ References ... 36
Annex 1 ... 37
Annex 2 ... 38
Annex 3 ... 42

List of figures

Figure 1 : Gilé National Reserve location ... 8
Figure 2 : Location of field trip activities ... 10
Figure 3 : Ehí - Russula cellulata (Photo: B. Guillot) ... 11
Figure 4 : Eyúkuli - Cantharellus miomboensis ... 12
Figure 5 : Kadhuve – Lactifluus sp. (Photo : B. Guillot) ... 12
Figure 6 : Namapeli - Lactarius sp. ... 12
Figure 7 : Namua - Othepo - Termitomyces schimperi (to be confirmed) (Photo: F. Montfort) ... 13
Figure 8 : Txaleia - Russula ciliata (Photo: F. Montfort) ... 13
Figure 9 : Exinamuhano - Cantarellus pseudocibarius (to be confirmed). (Photo: F. Montfort). ... 14
Figure 10. Block diagram of the data collection tools, from the creation of a form to the download of data ... 15
Figure 11 : Sampling protocol test in the GNR core area ... 17
Figure 12 : Mushroom collection ... 18
Figure 13 : Mushroom cleaning and cutting ... 19
Figure 14. Different steps in mushroom processing ... 22
Figure 15. Dried mushrooms packed (left) from Burkina Faso (bought in Oct 2019); ... 24
Figure 16. Boletus edulis on sale in Spain, packed in airtight pots ... 25
Figure 17. Dried khaduve and ehí. Photo: Tovolé Canana ... 25
Figure 18. Dried eyúkuli samples after drying during the mission ... 25
Figure 19. Discussions with the women mushroom group of Vassele ... 28
Figure 20 : Improved cookstoves in clay. Left: model spread by COSV some time ago around the BZ communities; right: locally hand-made improved cookstove from Burkina Faso) ... 28
Figure 21 : Tasting of packed dried mango ... 29
Figure 22. Air circulation through the solar dryer ... 31
Figure 23. Women practiced hammering of the nets to the grates ... 32
Figure 24. Basic drawings of a hot box ... 33
Figure 25. Drawings of model 1 (initial conception) ... 39
Figure 26. Photo of model 1 achieved ... 39
Figure 27. Drawings of model 2 (initial conception) ... 40
Figure 28. Photo of model 2 achieved ... 40
Figure 29. Improvised setting of 3rd model dryer, over an old house structure ... 41
Figure 30. Photo of model 3 at the selected location ... 41

List of tables

Table 1 : Edible mushroom identification.....11
Table 2. Mushroom processing steps: traditional vs standard method.....20

Glossary of terms

AFD: *Agence Française de Développement* (French Development Agency)

ANAC: *Administração Nacional de Areas de Conservação* (National Administration of Conservation Areas)

BZ: Buffer zones

CDD: Community Development Department

CGRN: *Comité de Gestão de Recursos Naturais* (Natural Resources Management Committee)

FAO: Food and Agriculture Organization

GNR: Gilé National Reserve

FFS-IGF : *Fondation François Sommer - Fondation Internationale pour la Gestion de la Faune*

NTFPs: Non-Timber Forestry Products

ODK: Open Data Kit

RH: Relative humidity

w/w: weight percentage over total weight

WHO: World Health Organization

1_Context

1.1. The Gilé National Reserve

The Gilé National Reserve (GNR) is located in the Gilé and Pebane districts, in the Zambézia province, in central Mozambique (Figure 1). The reserve was created in 1932, initially as game reserve and have turned into a conservation area since 2000. The core area covers an area of 283 600 ha and the buffer zone 152 800 ha. Climate is composed of a dry season from May to October and a humid one from November to April with mean annual rainfall between 800 and 1,000 mm. Temperatures vary from 13°C (minimum in June in average) and 37°C (maximum in October in average). Forest of the Reserve and its surroundings is Miombo dry forest, typical of this region, with presence of patches of clearings (called dambo) where hydromorphic soils are present. Miombo is characterised by species from the genus *Brachystegia*, *Julbernardia* and *Isoberlinia* (Campbell 1996).

Since 2009, François Sommer Foundation-International Foundation for Wildlife Management (FFS-IGF) has been co-managing the GNR with ANAC (*Administracão Nacional das Areas de Conservacão*) with the aim of conserving plant and animal biodiversity, and is working to rehabilitate the reserve by restoring its infrastructure, combating poaching and reintroducing animals (buffalo, wildebeest, zebra, etc.).

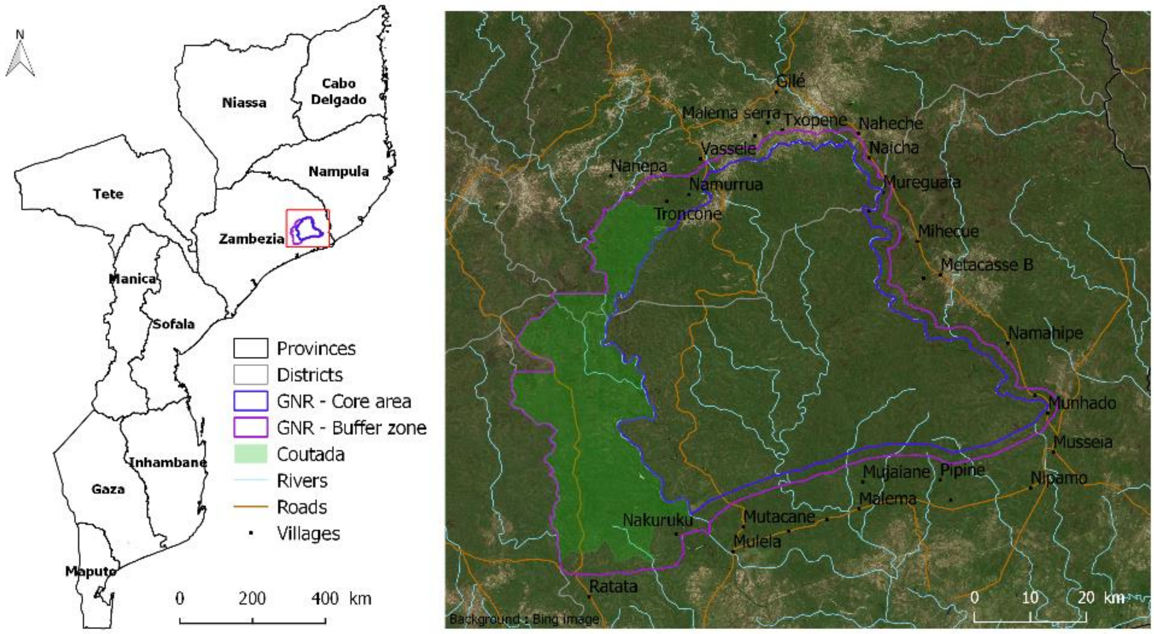

Figure 1 : Gilé National Reserve location

1.2. The NTFPs project

The project for the valorization and marketing of Non-Timber Forestry Products (NTFPs), coordinated by FFS-IGF started in 2017. This project was set up with the financial support of the French Development Agency (AFD) for a period of 30 months. The project aims to i) strengthen the GNR team capacities to protect natural resources, ii) promote the legalization and organization of the NTFPs sustainable use by local communities living in the Buffer zone, and iii) develop the NTFPs production by identifying and implementing methods, tools and channels of use and valorization.

Nitidæ has been working at the GNR in partnership with FFS-IGF since 2013, with the implementation of several projects: GNR REDD+ pilot project (2014-2017), MOZBIO project (2016-2019), ACAMOZ project (2018-2021). Through this consultancy, Nitidæ aims to support the NTPFs project by evaluating the potentiality of storing and commercialisation of NTFPs, namely wild mushrooms and honey by local communities living in the Buffer Zone of GNR and providing basic training to selected communities' members. The consultancy will capitalize on the work already done by the Community Development Department (CDD) to ensure that the service provides the needed elements to the GNR to move forward. The service will, on one hand: prioritize support to improve and transfer capacity on long term to the GNR team on NTFPs monitoring and sustainable production techniques; and on the other hand: realize pilot tests and market studies to help identify suitable technologies and prioritize the best options for NTFPs value chain development.

This mid-term report presents both the results and comments from the field trip carried out from 10th to 17th of February 2020 and from the remote technical assistance since the beginning of the consultancy.

2_ Field trip description

2.1. Objectives

Objectives of this field trip were:

- To observe current harvesting, transportation and cleaning practices to see where improvements can be made.
- Realize a pilot test of low-tech affordable drying to improve the product quality with a selected group of women.
- To test the sampling protocol for estimating biological productivity in the GNR.

2.2. Schedule

The field trip schedule is detailed as following:

Dates	Julia Artigas Sancho	Frédérique Montfort
Fri 7	Flight OUA-ADD	Flight CDG - ADD
Sat 8	Flight ADD-NPL	
Sun 9	Nampula - Gilé	
Mon 10	Gilé : 1st meeting, organization w technicians GNR	
	Meeting of selected CDD: Vassele	
Tues 11	Field visit to pick up mushrooms (around Vassele)	
	Construction of first drying grates and start process of 1st batch of mushrooms	
Wed 12	Field visit to pick up mushrooms (around Namúrrua-Troncone)	
	Construction of dryer support (1st batch, Day 2)	
Thu 13	Start process 2nd batch of mushrooms (1st batch, D3 ; 2nd batch D1)	Biological productivity estimation : sampling protocol test in the GNR (4 plots)
	Construction of 2nd dryer model	
Fri 14	Start process 3rd batch of mushrooms (2nd batch D2 ; 3rd batch D1)	Field visit to pick up mushrooms (around Txopene)
	Construction of additional grates	Biological productivity estimation : Sampling protocol test in the GNR (2 plots)
Sat 15	Look for packing options in Gilé	Biological productivity estimation : test sampling protocol in the GNR (5 plots)
	Start process 4th, 5th and 6th batches of mushrooms (2nd batch D3 ; 3rd batch D2 ; 4th batch D1; 5th D1 6th D2)	
Sun 16	(break)	
	Wrap-up meeting, group discussions (3rd batch D3 ; 4th batch D2; 5th D2 6th D2)	
Mon 17	(4th batch D3; 5th D3 6th D3)	
	Debrief meeting : Outcomes + way forward	
Tue 18	Way back	

2.3. Location

During the field trip, activities were mainly organized in three communities located in the northern part of the Reserve (Figure 1): Namúrrua, Txopene and Vassele. Mushroom collection with groups of women were organized in these communities. Three pilot driers were realized in Vassele. The sampling protocol for biological productivity estimation was tested in 11 plots in the GNR core area (near Namurrua) with the GNR team. Furthermore, the market of Gilé was visited to collect information about mushroom names, price, quantities, sales organization and packing options.

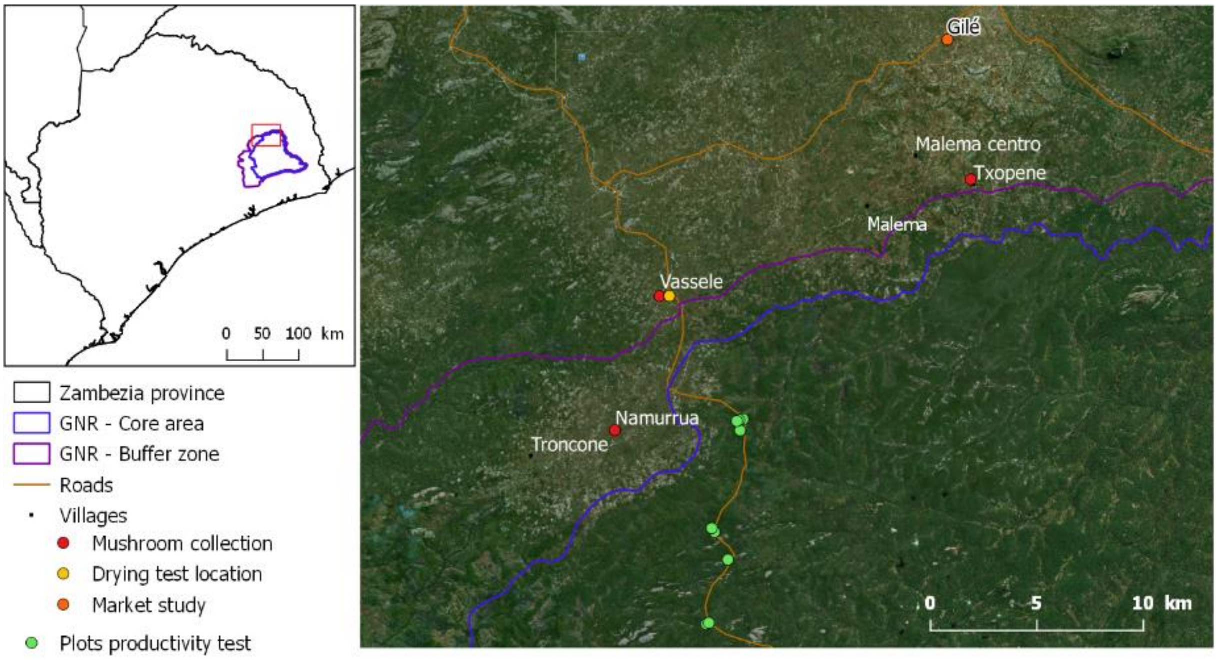

Figure 2 : Location of field trip activities

3_ Edible mushrooms characterization

3.1. Information on some edible mushrooms

Mushrooms are known as an important resource providing food and nutritional security and extra income to the rural communities in Africa. The literature mentions at least 120 mushrooms species on Miombo ecosystems (Malaisse, 1997). The inventory made by Romann in 2016 around the GNR mentions 46 species, used by the populations living near the Reserve. Most of the edible mushrooms are symbionts and live in symbiosis with trees (Ectomycorrhizal fungi) and few edible mushrooms are saprophytes (live off dead organic material) (Malaisse, 2017). In Miombo woodland, ectomycorrhizal fungi grow in a symbiotic mutualistic association with the roots of trees mainly from the genera *Brachystegia*, *Julbernardia*, *Isoberlinia* (Fabaceae) and *Uapaca* (Euphorbiaceae).

Previously, five species mainly collected and consumed by communities bordering the Reserve and with a market potential have been mentioned: Mtxekatxeka (*Amanita sp.*), Kathive (*Lactarius sp.*), Ehi (to be determinated), Namapele (*Lactarius sp.*) and Namua. (*Termitomyces sp.*) (Person, 2019). Here, we complete some identification, on the basis of the determinations of the previous studies (Romann, 2016; Malaisse, 2017; Person, 2019) and with the help of Bart Buyck (Associate professor at the French National Museum of Natural History) and Jerôme Degreef (Head of staff of the Fédération

Wallonie-Bruxelles in Meise Botanic Garden and editor of Fungus Flora of Tropical Africa[1]). In order to validate and continue the determination of edible mushroom, samples of each species will have to be collected, dried and analyzed by an expert.

Local Name	Family	Genus	Species
Ehí	Russulaceae	Russula	cellulata
Exinamuhano	Cantharellaceae	Cantharellus	pseudocibarius
Eyúkuli	Cantharellaceae	Cantharellus	miomboensis
Khaduve	Russulaceae	Lactifluus	edulis
Namapeli	Russulaceae	Lactarius	sp.
Othepo, Namua	Lyophyllaceae	Termitomyces	schimperi
Txaleia, Dxaleia	Russulaceae	Russula	ciliata

Table 1 : Edible mushroom identification

Local name: Ehí
Family: *Russulaceae* ; **Genus:** *Russula* ; **Species:** *cellulata*
Identification: B. Buyck
Ecology: Ectomycorrhizal species, associated with *Afzelia africana*, *Marquesia* spp, *Brachystegia* spp; dry dense forest, gallery forest, miombo (De kezel et al., 2017).

Figure 3 : Ehí - Russula cellulata (Photo: B. Guillot)

Lomwé name: Eyúkuli[2]
Family: *Cantharellaceae*; **Genus:** *Cantharella*; **Species:** *miomboensis*
Identification: B. Buyck
Ecology: Very common species in miombo woodland (except woodland dominated by *Uapaca* spp.) (De Kesel et al., 2017). Ectomycorrhizal species, associated with *Julbernardia* and *Brachystegia*. Possible association with the species *Dalbergia nitudila* (Fabaceae, nom lomwé: Evico); in more than 60% of the stations collected this tree was present nearby (1 m around the station).

[1] https://www.ffta-online.org/
[2] Vernacular names can group different species under one name. Several species of the genus *Cantharella* are called Eyúkuli.

Species from the genus *Cantharella* (Chanterelles) have been reported as the dominant species in the miombo woods of the Selous-Niassa Wildlife Corridor (Bloesch and Mbago, 2018).
Seasonality: High production in January and February (De kezel et al., 2017).

Figure 4 : Eyúkuli - Cantharellus miomboensis

Lomwé name: Kadhuve
Family: Russulaceae; **Genus:** *Lactifluus*; **Species:** *edulis* (to be confirmed).
Ecology: Ectomycorrhizal species, grow in Miombo woodland.

Figure 5 : Kadhuve – Lactifluus sp. (Photo : B. Guillot)

Lomwé name: Namapeli
Family: *Russulaceae*; **Genus:** *Lactarius* ; **Species:** sp. (to be determined).
Ecology: Grow in Miombo woodland.

Figure 6 : Namapeli - Lactarius sp.

Lomwé name: Othepo, Namua
Family: Lyophyllaceae ; **Genus:** *Termitomyces*; **Species:** *schimperi* (to be confirmed).
Identification: C. Romann
Ecology: Termitomyces mushrooms grow as symbionts in the termite nests, where they produce various enzymes to help termites digest lignocellulosic substrates. Grow in dense humid forest, open forest and savannah.

Figure 7 : Namua - Othepo - Termitomyces schimperi (to be confirmed) (Photo: F. Montfort)

Local name: Txaleia, Dxaleia
Family: *Russulaceae*; **Genus:** *Russula*; **Species:** *ciliata*
Identification: F. Malaisse
Ecology: Ectomycorrhizal species, associated with Caesalpiniaceae; open forest, miombo.
Seasonality: High production at the beginning of the rainy season (December-February) (De kezel et al., 2017).

Figure 8 : Txaleia - Russula ciliata (Photo: F. Montfort)

Lomwé name: Exinamuhano
Family: Cantharellaceae ; **Genus:** *Cantharellus* ; **Species:** *pseudocibarius* (to be confirmed)
Ecology: Sandy soil, growing in groups (station) in miombo woodland. Ectomycorrhizal species.

Figure 9 : Exinamuhano - Cantarellus pseudocibarius (to be confirmed). (Photo: F. Montfort).

3.2. Implementation of a data collection system

Provision of more specific and quantitative information about mushroom collection sales and consumption around the GNR is necessary for resource management and value chain development. However, it will require the collection and the processing of a large amount of information which can be very time-consuming.

During this mission, we evaluated the potential of the use of data collection system, Open Data Kit (ODK), to facilitate the collection of field information on edible mushrooms. ODK is a free, open source suite of tools that allows data collection using Android mobile and data submission to a server at the time of data collection. Two software tools of this suite will be particularly useful:

- ODK Collect is an Android data collection application, which replaces traditional paper forms. The application supports many types of questions (open, single or multiple choice, etc.) and answers (text, number, GPS location, image, sound). The forms once filled are first stored by the application ("offline" storage) before being sent to a server (ODK Aggregate). The application can work in the field without any connection to the Internet.
- ODK Aggregate is a web application that allows both sharing blank forms and centralizing those filled through ODK Collect. The application needs to be hosted on a server and connected to internet to work. Once the data is centralized on Aggregate, it is accessible through a graphical user interface allowing easy export (CSV or EXCEL format).

Before being deployed in the field, the forms must first be built from a spreadsheet software (such as Microsoft Excel or Libre Office Calc) and uploaded on the Aggregate server. Once available, they can be downloaded via the ODK Collect application by anyone with access to the server. Users can then proceed with the various surveys and return the completed forms once the work is completed. At this point, the collected data can be downloaded in spreadsheet format directly from the ODK Aggregate server.

The functionalities of ODK were presented quickly during the mission and could be supported remotely (if this collection system is adopted):

- The creation of ODK forms from a spreadsheet software.
- The operation of the ODK Collect application (connecting to the server; loading, creating and editing forms, form filling) were presented and explained.

- The operation of the ODK Aggregate server (adding blank forms; retrieving completed forms)

Three test forms were prepared during this mission:

- Collection: collector information, mushrooms vernacular name, photo, sites, harvest practices, collected quantities…
- Sales: names (sellers and investigators), date, village, age, location (market, road), mushroom vernacular names, quantities, prices…
- Consumption: names (consumers and investigators), date, village, age, quantity consumed, mushroom consumption frequency…

This data collection system is simple and can be quickly handle by the CDD team. Its deployment in the field requires: one survey coordinator in charge of managing forms and data collected, training of the survey coordinator in the use of ODK tools (1 day), equipping technicians with Android mobile phone, training the teams in its use (1 day). This collection system can greatly reduce the time and resources used in data collection and throughout the data management process, and also facilitates analysis.

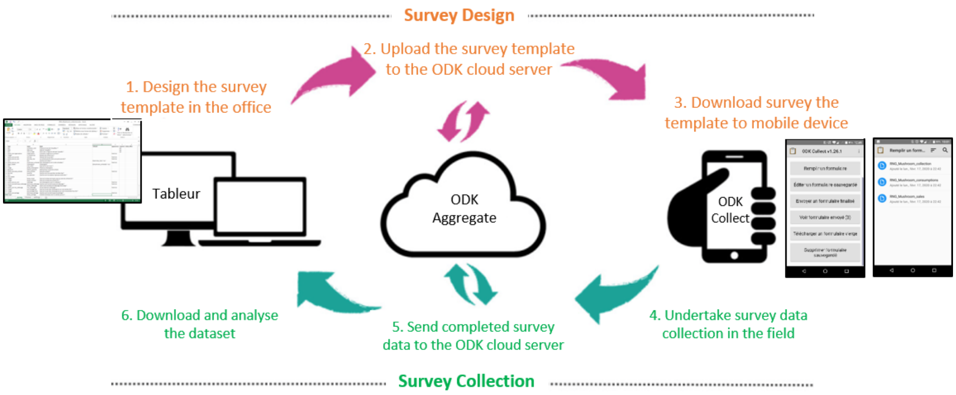

Figure 10. Block diagram of the data collection tools, from the creation of a form to the download of data

4_ Biological productivity study

4.1. Objective

The monitoring of biological productivity aims to produce knowledge on edible mushrooms species of the region (qualitative approach, list of edible mushrooms), and on their seasonality and production capacity (quantitative approach). These data are essential to define sustainable collection thresholds and feed along the time the sustainable management plan for mushrooms.

4.2. Methodology:

Biological productivity is defined as the total number or weight of mushrooms that fruit per unit area during the fruiting season (Pilz and Molina, 2002). Seasonal totals are necessary because many edible species will fruit repeatedly or continuously during a period of several months of favorable weather each year, therefore estimates based on one-time sampling represents an unknown percentage of the seasonal crop. Repeated inventories (monitoring, permanent plot) over multiple fruiting seasons are required to adequately estimate habitat or site productivity, because there is substantial annual variation, often weather related, in productivity among fruiting seasons. The high annual variability in production also necessitates long-term monitoring to detect statistically significant trends in productivity (Pilz & Molina, 2002).

<u>Sampling design</u>

The sampling protocol proposed is adapted from De Kezel et al. 2017.

Plot: Square permanent plot of 30x30m.
Plot location: Plot will be established in sites randomly selected. In order to avoid a bias caused by collections of other gatherers, the study sites will be installed in the GNR core area.
Plot quantity: between 15 and 20 plots
Frequency: Weekly sampling, throughout the entire rainy season (November-April) during 2 or 3 year consecutively (26 sampling per year).
Data collection: => Plots were completely and conscientiously covered in parallel strips (of 1 m).

- Each permanent plot will be described (floristic species, soil…) during the first sampling.
- Fresh weight and number of fruit bodies will be recorded per species in each sampling, using an electronic balance (0.1 g precision).
- All individuals who cannot be identified in the field will be collected and dried for identification.

The team in charge and the plot location should be chosen wisely to ensure that the scientific protocol is followed and to avoid collection in unsuitable zones or non-compliance with good practices after the monitoring.

4.3. Protocol test

During the field trip we test the sampling protocol in 11 plots in the GNR core area (near Namurrua) with the GNR team.

In these 11 plots, we recorded an average fresh weight of 209 g (between 56 and 866 g), i.e.1.7 kg/ha (between 0.5 and 6.9 kg/ha), mainly Eyúkuli. However, as said before, one-time sampling gives us only partial information, seasonal totals are necessary to estimate the biological productivity. In addition, as this survey was conducted during a period of low rainfall, the mushroom diversity and quantity per unit area recorded is probably underestimated.

We estimated the time for plot installation at 10 min and sampling time from 0.5 to 1 hour, with 2 people. The workload (with 15 sampling plots, 1 hour/plot and 26 sampling/year) can be estimated at three months (counting 22 working days/month) of full-time work for two people. Travel time between plots is the variable having the most influence on the total duration of the inventory. To avoid long walking times between plots, they can be placed within 1 km of a track. As a measure of economy and efficiency, permanent plots could be the same as those used for other ecological monitoring in the GNR (for example, forest regeneration, fire impact...).

Figure 11 : Sampling protocol test in the GNR core area

5_ Mushrooms harvesting practices

5.1. General information about harvesting

Who collects? Almost exclusively women (often accompanied by children for the knowledge transmission). The mushroom collection is not an opportunistic activity for them. Inversely, men can collect mushrooms only opportunistically, during other activities.

Collecting method: Collection is done in groups. Travel on foot to sites. No special harvesting method are used. The average walking distance from the village to mushroom picking sites noted during the three collection during the field trip is about one hour. The CDD team reports a great variability in walking distances between the communities (for example 5 min in Txopene and 2 h in Mulela). The average collection time noted is also about 1 hour. The walking distance to *Termitomyces* sites is certainly shorter since they are abundant in cropland around the villages (Bloesch and Mbago, 2009). Information on collection times are based on very few data and needs to be supplemented by more surveys.

Period: The collection extends throughout the rainy period from November to April.

Collecting zones: Since most of the mushrooms collected grow in the miombo woodlands or in older fallow lands, it is highly likely that communities living close to the GNR core area collect the mushrooms there, which is not allowed by the current GNR regulations (ongoing discussions could lead to adaptations of GNR regulations regarding NTFPs collection in the future). This represents a major challenge for the development of the mushroom value chain.

Figure 12 : Mushroom collection

5.2. Good practices

The Reserve team has been working for several months on the dissemination of good collection practices. These are already very well applied by women during collections.

- Women walk slowly and dispersed, which avoids trampling (harmful to the mycelium).
- The mushrooms are cut off where they joint the ground and not pull, so as not damage the mycelium below.
- The majority of dirt and debris are removed in the collected site with a brush: allows to leave as many spores as possible in the forest and also means dirt and debris doesn't get lodged in gills or pores, making them much harder to clean after transportation.
- Some fungi are left on the stations to allow them to finish their cycle or provide food for animals,
- Small mushrooms are left to avoid harvesting them before they have released their spores, the collection is focus on mature mushroom.
- They do not harvest more than they can use or sell (ensure optimal opportunity for mushroom to regrow year after year). Damaged or inedible mushrooms are left in site (can provide food for animals ...).

Comments on these good practices based upon field observation:

- There is a debate between two schools of thought on the best way to collect a mushroom and ensure the harvesting sustainability: cutting or picking (Bunyard, 2012). If cut appears to be a more benign way to harvest (since you soil is not disturbed) several long-term studies (Norvell, 1995; Egli et al., 2006) have found no difference in annual yields of mushroom plots harvested by either pulling or cutting. The most serious threat to mushrooms comes from habitat loss (deforestation, forest degradation, fire...) and perturbation (soil compaction, litter disturbance...) (Harding, 2008).
- Mushrooms should be collected in open basket made with local natural fibers rather than in basin or bag: this is to allow the spore dispersion during the trip and to preserve the

quality of the mushroom, by avoiding excessive moist conditions, and also over-heating of the mushrooms by the sun.

- Mushroom should be processed the same day as far as possible. If mushrooms are not processed within the following hours to the collection, part of them will be spoilt. Local communities are used to processing the mushrooms as soon as they are picked, so this is not yet an issue, but as processing in groups demands of more coordination, some delay may happen, resulting in bad quality dried product. This is especially true when the fresh product is placed overnight in a closed, humid space with poor ventilation; which is the case inside the CGRN rooms.
- The effect of the water quality used in mushroom processing is to be assessed, though it is hardly possible that clean water can be at the source of food contamination – dried mushrooms are meant to be boiled prior to consumption, so they will be sanitized at that point. The main challenge may be the compliance with national legal food safety standards, if applicable. At least to ensure the best affordable water quality and clear from solid bodies, for mushrooms cleaning, it is preferable to use water from wells and not from rivers, as wells water is cleaner and debris-free than river water.
- Dispose of mushroom trimmings and waste in a similar habitat to the one they were picked from, so as to maximize the possibilities for mushroom reproduction again (bring back by women the next day for example).
- Throw cleaning water in areas of vegetation / fallow land near the house: doing this could allow the development of fungus in these areas, thus taking them back close to the communities.

Figure 13 : Mushroom cleaning and cutting

6_Mushroom processing

6.1. Traditional vs improved processing methods

During the mission, discussions and work with the group of mushroom female collectors of Vassele took place. Our activities linked to processing were thus centered at the CGRN in this village.

The main objectives were:

1. To observe and propose good processing practices that are feasible and appropriate to the actual stage of development of the collectors' group
2. To design and build different solar mushroom dryers with participation of the communities. The most appropriate dryer design would be identified.

The table below synthetizes two processing paths that were put in practice during the mission: the traditional method that the collectors use to apply in order to dry mushrooms around GNR; and a standard method, as recommended by professional mushroom processing guides (Monterey Mushrooms, 2019; Mushroom appreciation, s.d.).

	Cleaning	Cooking	Slicing	Drying	Packing	Result
Traditional	Soaking into water and rubbing with hands	Boil from 30 to 50 minutes. No thorough wringing	No cutting	Sun drying 3-4 days on a mattress/plastic sheet. On rainy weather, drying at home (smoke)	Storage in clay pots	
Improved /standard	Brushing and rubbing smoothly	No cooking	Cut in 5mm thick slices	Sun drying 3 days on grates. On rainy weather, (soft woodfire dryer?)	Storage in airtight plastic or glass containers	

Table 2. Mushroom processing steps: traditional vs standard method

6.1.1. Cleaning

The traditional method is to plunge the fresh mushrooms in water and hand rub them. More recently, women groups have become used to brushing the mushrooms to remove soil or sand residues. They do so prior to the water cleaning step.

Following the standard method, instead, soaking the mushrooms is proscribed. Due to the high porosity of mushrooms, they are able to absorb the water around them. This will result in swelling, thus loosing part of the taste after expelling the excess water. This is visible when the washing water is rejected: the liquid got colored and a characteristic odor.

Standard cleaning should be done with a damp cloth and/or a brush. Also, they can be shaken in a colander to loosen off the dirt. During the field mission, cleaning by brushing only was prescribed.

The main reject materials are small leaves and sand that can be efficiently removed with a brush. The advantage of the brush is that it can clean in the narrow spaces between the membranes below the mushroom hats. The damp cloth seems also an appropriate solution, for example in case of persistent dirt (rests of soil).

6.1.2. Cooking

Communities around Gilé area use to cook the mushrooms that will be dried afterwards, in boiling water. However, this practice is again not prescribed through the standard method, for the same reasons stated above.

Women put water in a pan and start a fire in the middle of three stones. When water starts boiling, the mushrooms are introduced and left them simmering for a time between 30 and 50 minutes; until the cook considers they are ready.

After boiling, the resulting mushrooms are damp and look saturated with water, but when the weights of the product before and after cleaning and cooking are compared, the cooked mushrooms happen to be lighter than the fresh ones. This weight loss is around 20% over fresh weight. It could be explained by the breaking of the mushroom cell membranes, which incurs in liberation of the water stored inside.

On the other hand, the boiling water gets a vivid color. It contains many elements liberated by the mushrooms. This water is not recycled by the women, though it has a rich taste and probably contains some nutritional elements like mineral salts, which are indeed present in the dishes that use fresh mushrooms. The boiling water could be used in daily cooking (for example use it in the preparation of sauces like *matapa*; or even integrate the *xima* mixture.

When asked why cooking is a compulsory step before drying the mushroom, women explain that this has been always done this way. Also, some added that some mushroom that are toxic fresh, become nontoxic once cooked.

Soaked mushrooms may develop molds during the drying process, as the moist and heat are persistent in the mushroom when left to dry, and constitute favorable growing conditions for them. It is possible that cooked mushrooms, once dry, are more bound to develop molds and then a shortened shelf-life.

However, cooking seems to be a step considered essential by communities. When they were suggested abandoning the cooking step, all looked skeptical and asked if the dried mushrooms would be healthy to eat. Changing this traditional habits if required by some market opportunities could be an important part of the work within women collector's groups.

6.1.3. Slicing

As witnessed by the women, they never slice the mushrooms prior to drying, they directly dry them whole after cooking.

During the processing sessions, instructions were given to slice the mushrooms 0.5 cm thick. To the extent possible, the slices shall be done following the profile plane of the mushroom. By doing this, they retain the form of the mushroom and are more visually attractive. Women could perform this operation easily with their knives.

Figure 14. Different steps in mushroom processing

6.1.4. Drying

Mushroom is traditionally dried on improvised surfaces (mattress, plastic sheets, PP bags) laid on the ground, on a sunny zone. Once boiled, mushrooms are brought out from the saucepan and straight laid on these surfaces. Drying takes 4 to 5 days when following this technique. In case of rainy weather, the product is wrapped-up and brought to the interior of the house. If the bad weather conditions persist, the mattress holding the mushrooms is hung over a small fire or hot point in the house, thus following the drying process. However, as the mushrooms get a smoked taste, this path is not really appreciated by the communities.

Standard drying conditions are to keep the sliced mushrooms in a well-ventilated space, with dry and hot air passing through and wiping out the surface water as it comes to the surface of the product. The indicated optimum temperature is 65ºC. Higher temperatures would degrade some components of the mushroom, lower temperatures would just slow down the drying process. Fresh mushrooms contain 90 to 95% water. A quality dry product shall have 7 to 10% of residual humidity. Limits indicated by Codex Alimentarius are slightly above: dried mushroom shall contain less than 12% water (FAO, 1981)[3]. This means that the product shall experience 89 to 95% mass loss[4].

Sun-drying is one of the commercially accepted methods to preserve foods, and the case of the Gilé zone, the most appropriate to dry the mushrooms. Sliced mushrooms take 3 days to get completely dry, if sun-dried in good conditions. However, because of limitations on insulation time, maximum temperature achieved and relative humidity of air, the maximum dryness degree could not be attainable only with sun-drying. Drying happens when a water-containing product is placed in a dry atmosphere, for water to move in the sense of the gradient. Thus, in wet tropical environments, the product may need additional measures to get fully dry (Mushroom appreciation, s.d.).

Women are familiar with identifying the right moment to end the sun drying. Dried mushrooms crack when a flexion effort is applied to them, just like a biscuit does. If the product is still flexible, it is not yet dry enough.

[3] The Codex Alimentarius, or "Food Code" is a collection of standards, guidelines and codes of practice adopted by the Codex Alimentarius Commission. This body was established by FAO and WHO to protect consumer health and promote fair practices in food trade.

[4] Calculation steps are shown in Annex 1.

Over the mission, drying tests were undertaken on 6 different batches of mushroom. 3 different configurations of solar dryers were tested. The main differences of the dryers proposed, compared to the traditional way of drying, are:

- Drying in grates
- The product is placed at a distance from the ground

These modifications promote air circulation around the product and improve the hygiene conditions. The result is a homogeneous dry product which is ready in just 3 days. A discussion on the steps followed to design and build the dryer is available in Annex 2.

During the pilot processing sessions, weights of the fresh and dry product were recorded. The results suggest that the final water content of the product is around 11% after 3 days of sun-drying. Detailed results of the drying tests are available in Annex 3. Average weight loss was 91%; thus, the drying results are good but moisture levels are on the high-side of the limits. Final moisture could be lowered once the definitive drier model is adopted, and users have enough practice with drying methods.

No significant differences were found between cooked samples and non-cooked ones, or comparing dry-cleaned and wet-cleaned in terms of drying time and loss of weight. More testing would be needed to determine the effects of these steps on the product drying rate. The most important difference is the final aspect of the mushroom: cooked samples become remarkably darker compared to the color of the fresh product. Mushrooms that were not cooked kept the original color and an intense appealing aroma – no longer present in cooked ones as the aromas went away in the boiling water.

6.1.5. Packing

Dried mushrooms are traditionally stored in clay jars at home. This kind of container is not appropriate for these products, as the clay itself retains some moisture and promotes the development of molds (see photo in Table 2 au-dessus). Also, the jar is open which doesn't prevent ambient moisture to be in contact with the product, which can finally absorb humidity back.

Standard packaging for mushrooms shall guarantee airtightness, in order to preserve the quality of the product as long as possible. The packed dry product shall be kept in a dry, fresh and dark place. The shelf life of the product can vary much depending on the hygienic conditions followed during processing and packing, and the storage conditions. Commercial dried mushrooms indicate six to twenty-four months of best before dates after the packing date.

Figure 15. Dried mushrooms packed (left) from Burkina Faso (bought in Oct 2019); (right) from Uganda (bought in Feb 2020)

During the mission no flexible thermo-welding plastic was found available in Gilé. All the plastic bags available in the markets seemed too thin to be manipulated with a heat-welding source; so not appropriate for products addressed to urban grocery stores. More diversity of packaging shall be easier to find in bigger urban centers, like Nampula and Quelimane. Before all, the main stores in Gilé were contacted to inquire about the possibilities to link supplies from the big towns to Gilé. The owner agreed to facilitate the retail commerce (re-sales) once we identify a specific package and a supplier.

However, rigid plastic packaging could be found in the markets of Gilé. 10- and 15-Liter capacity containers of palm oil are resold and constitute an appropriate and cheap container to store the mushrooms. The lid is of the same type than the one in Figure 16 below. This kind of package is already used for dried mushrooms when sold in big quantities (for example restauration). After the mission, medium-sized plastic boxes for domestic food use ("Tupperware" type) were delivered to the Vassele mushroom group to pack the dried mushroom, by following dry cleaning steps (Figure 17).

Figure 16. Boletus edulis on sale in Spain, packed in airtight pots

Figure 17. Dried khaduve and ehí. Photo: Tovolé Canana

The samples produced during the mission were put in plastic zip food bags and tagged. They were preserved in this package during 1 month and then open to test the moisture content in a lab setting.

Figure 18. Dried eyúkuli samples after drying during the mission

It shall be stressed that packing and storage are critical steps. Because of the high porosity of the mushrooms, the product can still evolve depending on the ambient moisture. If the dried mushrooms are kept in a damp ambient, or the packaging is not perfectly closed, mushroom can absorb humidity; and inversely, if the ambient is dry it tends to become even drier. Some flexible plastics allow air to pass through, even if they are not visibly open. For example, the plastic bags in Figure 18 were hermetically closed but put one month in a dry atmosphere, and the humidity of the product decreased from 11% to 6%. Care must be taken in the choice of the appropriate plastic packaging, not every material will guarantee the stability of the product.

6.1.6. Good processing practices

An organized processing activity is often a guarantee of a safer food product than a traditional, anonymous-sourced product. The NTFP project aims at building a value chain that would increase not only quantities available to the markets, but also quality of the product so that it can reach a more qualified market and attain better unit prices: all without omitting that communities would directly benefit of the knowledge and be capable to reproduce the good practices to better preserve the mushrooms at home. Processing shall be done in a way to maintain minimum hygiene levels:

- All the processing materials must be clean (knives, grates, slicing surfaces, floor…). These steps are currently not followed systematically but would not be difficult to integrate to the processing routine. They have already been practiced during the mission.
- Operators must wash their hands with soap before cleaning + slicing (wooden surface?) + prepare the grates + touch the product during drying. During the mission, we talked about the importance of hand washing and put into practice. Women pointed at the lack of soap for personal use for themselves and their families at home. This may be a hot point in the future. Also, the soap used during the mission (the most abundant in markets, sold in sticks) was not found to be of good quality.
- Even if, as said, boiling may not be advisable in some cases, it cannot be denied that after boiling, mushrooms are sanitized. There are no other steps at high temperature. If cooking is to be practiced, all the processing steps after it shall be followed at the best hygienic conditions possible. If not boiled, then all the processing chain must be kept highly clean. This includes, for example, using clean and appropriate surfaces for each step. In the actual stage, the group lacks of surfaces for cleaning the mushrooms, slicing and put on the clays. All the operations are currently done on the ground, while the hangar of the CGRN could be a good space to host the processing steps after boiling. While inert surfaces are the best (stainless steel, silicon, glass…), they are not a realistic option in the present case. Rigid plastic can be a good option for every step involving low temperature, and is generally accepted in contact with the product. Hard-wooden surfaces could also be a good balance between hygiene, durability and economy, as processing surfaces but not as containers; also, tenure to molds must be tested.
- Presence of third persons should be forbidden near the processing zones. This means that children and strangers should not be allowed to access the processing zone while the operators are working.

6.1.7. Conclusion on processing itinerary

Traditional and standard processing methods show a variety of differences, and each of them has a reason to be. The advantages and disadvantages of each practice have been presented above.

It is clear that there are multiple advantages in adopting improved solar drying and packing methods that are appropriate to preserve the quality of dried mushrooms longer – and avoid molds, which are a visible sign of poor-quality product. Women in the Vassele mushroom group acknowledged that the new dryers were more efficient than the traditional ones and showed interest in adopting the new setting. They also appreciated the concept of slicing the mushrooms and witnessed that the drying process is faster in this form; and understood the importance of an appropriate packaging to preserve the product and sell it to a more demanding market.

However, whether the standard path to clean the mushrooms shall be adopted, or the traditional cleaning and cooking method should remain, is less certain. Women were surprised about the possibility to not cook mushroom and not even cleaning them. They still never tried doing so by themselves, and never consumed non-cooked dried mushrooms. Some showed fear about the advisability of eating dried mushrooms this way – but we did not feel a very strong opposition to the idea, so it is possible that a breach could be found. It is also possible that drying non-cooked mushrooms can be applied only to some species – for example, only those who show no visual ambiguity between edible and toxic species. Even in this case, if the hypothesis of toxicity disappearing through cooking proved true, dried mushroom are meant to be cooked afterwards, so cooking before drying does not seem necessary anyway. On the other hand, eliminating cooking and wet cleaning would not only ensure that a maximum nutritional and flavour elements remain on the product; it would also simplify the processing chain, save time, water and wood and thus have less impact in the daily lives of women and the environment. The dry-processed mushrooms are more attractive as they keep a clear color and a suggestive aroma (see Figure 18 and Figure 17).

Wet cleaning, though, could be an interesting possibility to bring back the mushroom growth near the population sites, as indicated above.

The definitive answer to this dilemma may be probably driven by the market demand: if final target buyers do appreciate standard dried mushrooms, which show a more intense aroma, attractive color and better nutritional values, then cooking step (and probably also wet cleaning) would no longer be practiced. Inversely, if target market still sees an advantage in processing the mushrooms through a wet and hot process, then these steps shall be maintained. There is no technical incompatibility in finding intermediate solutions and mixing steps from the standard and the traditional method. This question will be discussed further during the next months with the project team and once the market study data will be available.

A document on good collecting and processing practices has already been prepared by GNR team. This document will be reviewed and completed by Nitidæ, based on the field observations, discussions with the communities and technicians, and conclusions taken.

Further challenges were identified during this mission, regarding the available materials and facilities for processing: women lack of an appropriate processing place which guarantees minimum food safety and hygiene standards. This challenge can be partially addressed by moving critical processing activities (slicing after cooking, laying the slices on the grates) in the CGRN hangar, which facilitates a separation from soil sand and strangers. However, among the 14 selected beneficiary communities, only 6 feature a CGRN building; so an appropriate solution shall be found for the 8 others. Also, female processors shall observe hygienic practices such as washing hands with an appropriate soap. Up to now, the groups received one knife and one brush per member. The group of Vassele was provided with a saucepan, two plastic containers (old oil buckets), two open buckets and a colander. Women have some chairs and a bench at their disposal, belonging to the CGRN – but they are not sufficient for all, and they tend to not use them. Some additional working surfaces should be provided for them to work comfortably and place the product in clean surfaces at every step. This equipment may take the form of trays, shelves, tables, buckets, stools, additional knives and brushes… It shall be stressed that all processing materials must stay at the processing site (in this case, the CGRN). The strategy of giving one member of the group the responsibility over one single tool is not effective as the designed person tends to keep it with her and bring it home – but not taking it back to be used by the group as soon as needed.

Finally, if the cooking step is to be preserved, it would be advisable to build an improved cookstove in clay (bigger format than the clay improved stove that was spread some time ago in the zone; see Figure 20-right). Women could build it themselves and even replicate this at home. Improved cookstoves can save 30 to 60% of wood, thus participating to the reduction of the environmental impact of the activity. They also incur in time savings and are less harmful than traditional 3-stone fireplaces.

Figure 19. Discussions with the women mushroom group of Vassele

Figure 20 : Improved cookstoves in clay. Left: model spread by COSV some time ago around the BZ communities; right: locally hand-made improved cookstove from Burkina Faso)

Figure 21 : Tasting of packed dried mango

6.2. Development of improved solar dryers

6.2.1. Available materials

After a first approach to the dryer conception principles, a list of construction materials was developed, with the pros and cons discussed:

- The product shall dry on a **net/knitted material**, so that hot air can pass through. Materials available around Gilé are:

Material	Size of the hole	Tenure	Hygiene/social
Mosquito net	Good	Good tenure to rain and washing. Good resistance to weight	Not conceived to be used for food purposes
Metallic grid	Good (mosquito net model)	Bad tenure to exposure to humidity. Good resistance to weight	The zinc protective layer may loosen and adhere to the product
Mosquito Plastic net	Good	Good tenure to rainy weather and washing. Average resistance to weight.	Good stability in contact with the product, no absorption of odors/dirtiness
Thin cloth	Good / too small	Good tenure to rainy weather and weight.	May absorb odors if no thorough cleaning Colorants in the cloth may interact with the product

Thus, **mosquito plastic net** was selected. Price of 1 square meter is 100 Mt which was considered correct.

- The grates shall have a **frame**. **Wood** is the easiest available material around Gilé, given it that there are not metallic constructors in the zone – so welding is not possible. Also, in terms of durability, acceptability and cost, wood is the most indicated. Case of considering metal frames, it is important to maintain a light structure and seek a solution for the corrosion problems linked with metal (stainless material would be far too costly). Wooden frames would be assembled with nails (not screws) to keep the construction as simple as possible, and feasible to the communities in the buffer zone.

The type of wood used can make a big difference in the production cost (time, money), ease of use (weight) and durability of the dryer components. Hardwood commonly used in the zone (*umbila*) is very appreciated in furniture construction, but no longer abundant in the buffer zone; thus, its market price is high. It makes heavy structures, so work on this material takes time due to its compacity. On the other hand, it is not attacked by borers. Other local timber sources are available, though, featuring intermediate properties – and with the advantage that most of them are accessible at no cost. Construction of a drier does not need of noble wood, though durability of the material needs to be balanced to the production costs. Priority should be put on the material for the supports, as it is in contact with humid soil and is more difficult to replace than the grates.

- The grates shall be placed at a distance from the ground. Reasons:
    - Avoid contact with the ground (humidity, insects)
    - Facilitate ventilation (more air convection the more separate from the ground)
    - Facilitate manipulation from users (ergonomic)
    - Avoid opportunistic access (bigger animals such as goats, hens...even children)

  The material to build the supporting structure of the grates was **wood**, for the same reasons that were stated above.

- In order to concentrate the heat on the zone of the grates, **covering with a transparent surface is recommended**.

Material	Availability	Tenure	Hygiene/social
Glass sheet	Not available in Gilé	Good tenure to weather conditions, easy to clean, but very fragile	Optimum hygienic material Heavy, expensive, dangerous to manipulate due to danger of break
Plastic (plexiglass) sheet	Not available in Gilé	Good tenure to weather conditions, semi-flexible, easy to clean	Easy to manipulate (no need of frame) Risk of being diverted for other use
Flexible plastic (rolled) sheet	To check in Gilé (Available in Nampula)	Good tenure to rainy weather and washing. Average resistance to weight.	Easy to manipulate

Flexible plastic sheet seemed the best option, but the project team achieved to get a rigid plastic sheet, available in Nampula only. So, both materials were tested in the dryers.

It is important to maintain and promote the circulation of air. The cover of the grates shall always be conceived in a way that humid air, carrying the water that was contained in the mushrooms, can go out easily. Thus, some space shall remain open through the lid.

- To enhance heating up of fresh air, adding a hot surface below the space of the grates is also recommended. The hot surface can be made up of metal, wood painted black, or flexible black plastic. These discussions took place already on the field, and flexible black plastic was tested. But a metallic surface can be a good choice as it is more rigid (better tenure) and available in Gilé at a fair cost, in the form of corrugated galvanized sheets.

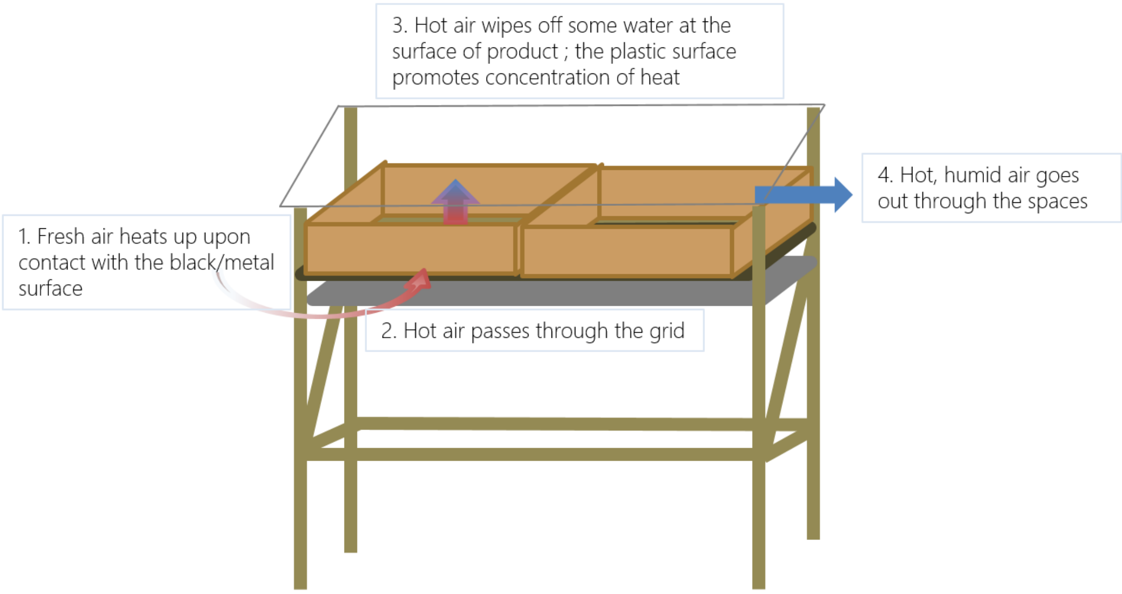

Figure 22. Air circulation through the solar dryer

An illustrated description of the different models of driers tested is available in Annex 2 (page 38).

6.2.2. Workforce

The dryers have been designed as simple as possible to build, so that they can be built in the different villages around the buffer zone. Wood can be supplied locally, and the rest of the materials are available in Gilé all the year long.

Wood quality may be an important factor in the building process and the total cost of the dryer. The wood used during the mission was *Pterocarpus angolensis* (*Fabaceae* – Lomwé name: *Umbila*), a very hard and compact wood. Thus, it was not easy to work on it, as it was necessary to hand-perforate holes instead of direct hammering the nails. As we built the dryers, we were joined by some curious men that felt comfortable to help at building, even if they were not craftsmen.

Women of the Vassele mushroom group were also assisting at the first stages, then quickly lost interest – partially because of lack of time (they could not stay all the day with the mushroom activity, as they had other obligations), and in part also because they did not expect to be useful for the building. Craftwork is essentially a men's task in these communities; however, when they were suggested to help at hammering the nets to the grate frames, some of them agreed and were happy to try the experience.

Figure 23. Women practiced hammering of the nets to the grates

One GNR technician also assisted us during the works, and he participated to the discussions about improvements and selection of materials. Thus, he can guide further the communities in the construction of more solar driers.

6.2.3. Drying during the night

In GNR, solar resource to dry is only available from 7 AM to 5 PM. The rest of the time, the product must be stored in a closed place – the option chosen is the CDD building. However, the room where mushrooms were stored was not ideal to host the product. The room remains humid in the rainy season due to lack of ventilation and a hot source.

A similar problem can be encountered if rain is persistent during several days.

Better opening the windows of the room (now blocked) to promote ventilation during the day would certainly help; or even building a more appropriate place to host the processing activities including drying. A certain alternative to this could be to build a hot box (or basic dehydrator). See Figure 24 below. The box would be a metallic cupboard containing several grates compiled. A mild heat source (embers) would be placed below, inside a fireplace built in clay. Combustion gases would pass through the space in a double sheet, and be evacuated out through a chimney. The hot box shall be ventilated as well, to allow fresh air to circulate in and go out in the room. This setup would be undeniably costly (compared to the rest of the equipment) and add some complexity to the overall process (need of one person surveying overnight), but would guarantee appropriate drying conditions during rainy periods and thus eventually avoid spoilt product for this cause.

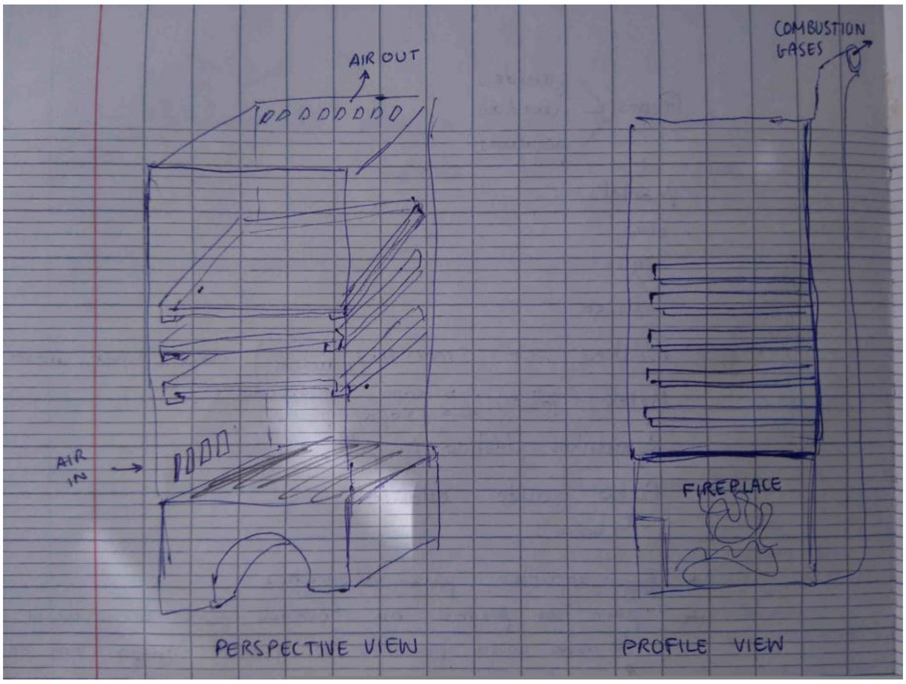

Figure 24. Basic drawings of a hot box

A second alternative could be a closed box with forced ventilation, by using a small fan (for example, a computer-type fan that can be powered with solar or conventional alkaline batteries). The walls of the box would just keep the product away of foreign contact and better drive the conveyed air. The box can be built in wood or even knitted walls using *capin*. This option relies upon elements who are not available in the zone (fan), but it should not be difficult to find and implement by locals. An additional risk is the robbery of the high-value components (fan, batteries/panel, wires).

7_ Conclusion

CDD team's on-going work with women groups to improve knowledge and monitor wild mushrooms harvesting is necessary to ensure their effective management in the future. During the field trip we saw that the dissemination of good collection practices by the CDD team is effective, as these are already very well applied by women during collections.

Based on previous studies, the identification of some species collected in the field trip has been confirmed. This work should be continued in order to determine all the main species regularly collected and consumed by communities bordering the Reserve. A large amount of data is collected by the CDD team on harvest, consumption and sales of mushrooms, which could be facilitated by the implementation of a data collection system using ODK. A sampling protocol to estimate biological productivity was tested, and proved to be easy to implement in the field. Its deployment on the field through a longer sampling period would allow the estimation of the production potential in the RNG and buffer zone.

On the processing side, different configurations of solar dryers were built with the help of the communities and the CDD team in Vassele, then tested. The drying tests yielded good results: 3 days of drying compared to 4 to 5 days when traditional drying is used. The moisture content of the finished product looked acceptable (around 13%), though it could be improved for more stability.

Prior to drying, women are used to wet-clean and cook the mushrooms, though this is contrary to the standard recommendations (only dry-cleaning). Wet procedure is the only practiced by the communities at this stage, and so can be at the buyer level; even if dry procedure yields a tastier, safer, low-carbon and nutritionally richer product, further research on acceptability of the dry-processed mushrooms shall be undertaken. However, the conclusions at this point are only partial as just one mushroom species could be processed (eyúkuli). Observation on processing of other species shall be deepened.

Women in the mushroom group of Vassele showed themselves receptive to new methods and appreciated innovations such as drying in grates and slicing the fresh mushrooms. However, there is a lack of processing material and some organizational measures shall be put in place to ensure a responsible use of materials and guarantee hygienic conditions. Overall, the community in Vassele is willing to collaborate, including men and local authorities, which is a very positive point.

Further technical assistance will be given remotely, on the above points but also on the choice of packaging and depending on the conclusions of the market study ongoing. Next deliverables shall be:

1. A note with comments on GNR roadmap for mushroom value chain,
2. A processing manual with drawings/schematic/photos, in Portuguese, including Good collection and processing practices,
3. A final report (Including market study and strategic recommendations for Mushroom value chain development).

As a general recommendation for further work, sustainability of the value chain and protection of the Reserve would be assured if mushrooms were grown instead of picked. Indeed, a growing and well channeled interest on mushroom could be an asset to promote conservation of forested areas in the buffer zone. For this, further research shall be engaged / based on the knowledge from other species, i.e. shiitake, porcini… that are already applied elsewhere in Africa with proven results.

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Annex 1

Calculation steps to loss of weight in drying to a set residual humidity – application to mushroom case:

Best case calculation scenario: low initial moisture, high residual moisture

100g of mushroom containing 10g of dry matter and 90g of water

When dry to 10% moisture, there is 1.36 g of residual water in 10g of dry matter: 1.36 + 10 = 11.36 total weight of dry product → 1.36 / 11.36 = 10% moisture. So product lost 90 – 1.36 = 88.64 g of water

→ *Almost 89% weight loss*

Worst case scenario: high initial moisture, low residual moisture

100g of mushroom containing 5g of dry matter and 95g of water

When dry to 7% moisture, there is 0.38 g of residual water in 5g of dry matter: 0.38 + 5 = 5.38 total weight of dry product → 0.38 / 5.38 = 7% moisture. So product lost 95 – 0.38 = 94.62 g of water

→ *Almost 95% weight loss*

Annex 2

Conception and construction of appropriate solar dryers

The process of conception and construction of dryers followed a participative approach, through these steps:

1. (previous to field mission) Remote discussion with GNR project officer about available materials and basic design guidelines (GNR project officer + Nitidæ mission officer)
2. (previous to field mission) Provisional designs and dimensioning of dryers. Two types of dryer
   2.1. Table dryer (support + removable grates + rigid plastic removable cover)
   2.2. Full dryer (no grates, net is embedded in the support structure + rigid plastic removable cover)
3. (previous to field mission) Collection of materials and order of wood pieces (GNR & Nitidæ staff)
4. Construction of model 1 grates (GNR & Nitidae staff + communities). Grates used to dry on improvised supports.
5. Construction of model 1 support structure. Model 1 grates moved to support structure and drying tests
6. Discussions on model 1 design and proposals to apply on model 2 (GNR & Nitidae staff + communities)
7. Modifications of model 2 applied, construction of model 2 achieved (Nitidæ mission officer + GNR technician + communities)
8. Start of drying tests on dryer 2
9. Discussions on the 2 dryers and proposal of a 3rd model (RNG & Nitidæ staff + communities)
10. Construction of 3rd model
11. Discussions on improvements to model 3 (end of field mission)
12. Start of drying tests on dryer 3 (RNG technician and officer + communities)

Below can be found pictures of the primary designs and the final pilot dryers built. The primary idea was to build portable dryers so that women can handle them by themselves, bring it into the CDD building once the day is finished and take it back again the following day. Model 1 constructed is a structure with capacity for 2 grates, which can be removed independently. This facilitates the operation (placing the fresh slices on the grates, taking out the dried product, separate different batches of product by clay).

Dimensions indicated in the drawings are not those finally adopted on the field. Grates had exterior dimensions of 70x80cm; and included pieces of wood on the top of the side walls, to support in turn the rigid plastic that was placed above. Bulk dimensions of the support were 150x90x82 (length x wide x height).

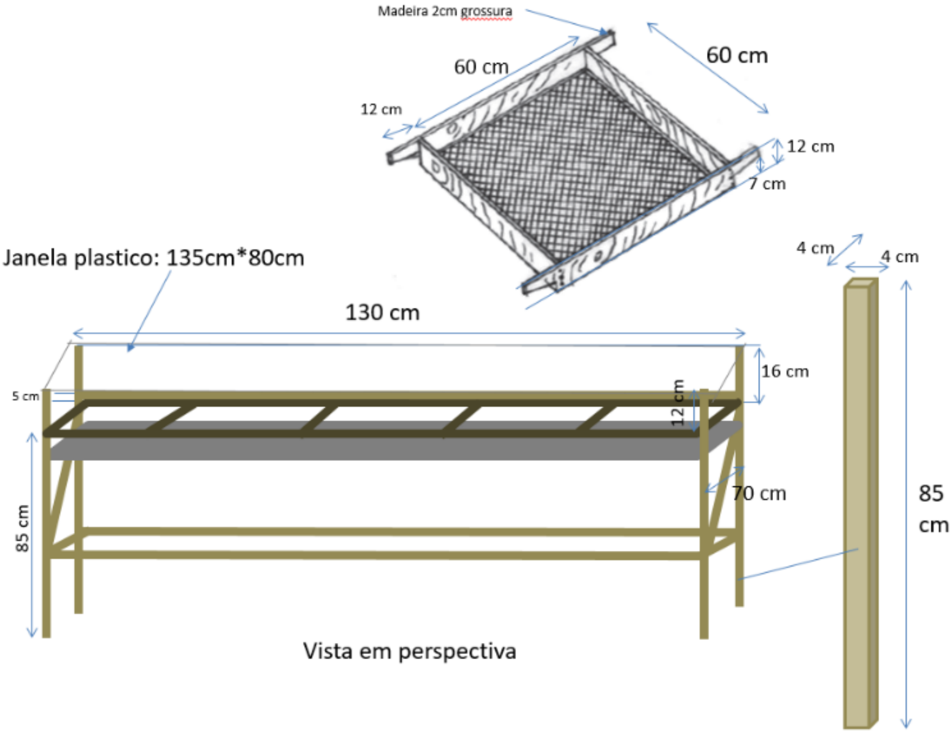

Figure 25. Drawings of model 1 (initial conception)

Figure 26. Photo of model 1 achieved

Upon field experience and first discussions with the users, it was observed that a main challenge to use of model 1 was the heavy weight of the support structure, and big dimensions. Indeed, the wooden sticks used were made of a very massive wood and the whole structure, shaped like a table where the grates shall be placed, was quite heavy to be moved by two persons. Also, it was difficult to make the dryer pass through the door of the CDD, as it was just as wide as the door frame. Finally, the structure of model 1 alone took too much space in the CDD room, so a second dryer of same dimensions was considered too big. Model 2 took these considerations into account and was built with smaller dimensions (space equivalent to one grate).

The black plastic sheet was tested on this dryer (fixed to the legs of the dryer with nails). But the result was poor: the plastic got torn off quite easily with any wind blow. The conclusion is that metal sheet should be prioritized.

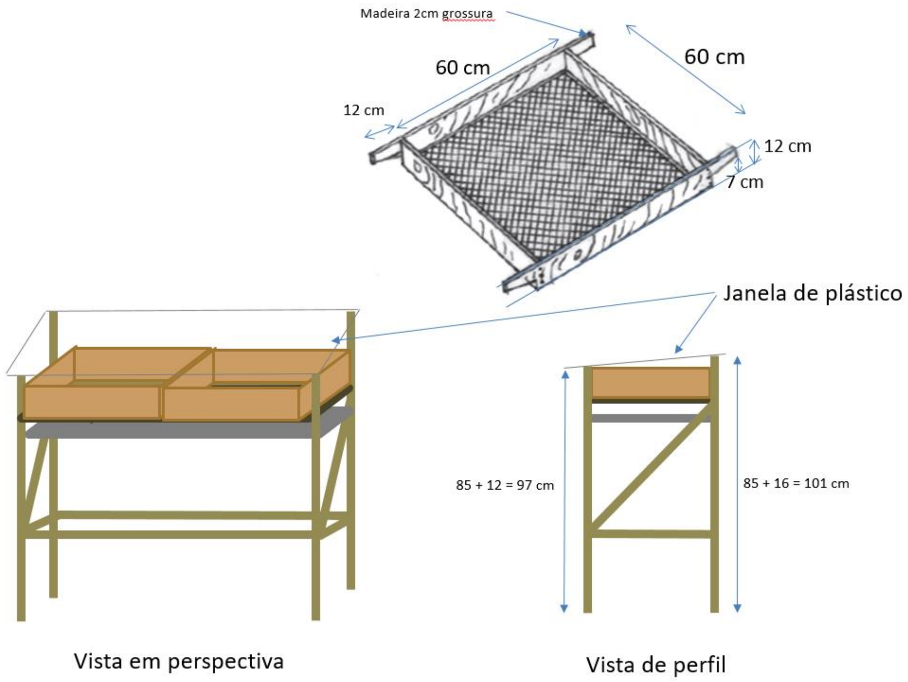

Figure 27. Drawings of model 2 (initial conception)

Figure 28. Photo of model 2 achieved

As explained above, during the drying tests people from the community pointed out that the dryers were not high enough to prevent the product to be eaten by a goat. So the grates should be even higher. Also, a fixed structure to support the grates would make possible to manipulate only the grates every day, and minimize efforts. The challenge of a fixed support outdoor was the danger of theft, and the access to the field where the supports shall be put in place. The only sunny open space around the CGRN is a parcel belonging to the *régulo*. Luckily, this man is engaged with the project and supports the activities of the mushroom women group. We got his permission to fix a wooden support in a selected area.

Figure 30 shows the layout of model 3 at the last day of the field mission. The structure of the final model was built, and so some grates as well. Instructions were given to improve the stability of the grates by adding some pieces to prevent the grates to slide – which would also become a lifting support for the plastic cover. Also, a corrugated iron sheet shall be fixed with nails to the support, a few cm below the grate level.

Figure 29. Improvised setting of 3rd model dryer, over an old house structure

Figure 30. Photo of model 3 at the selected location

Annex 3

Processing parameters of the pilot batches

As long as fresh mushrooms were made available during the mission, processing tests were conducted. 6 different batches were processed, all using the same mushroom species, eyúkuli, which was the main available during this period. The processing parameters are shown below:

Batch	Fresh weight	Cleaning	Cooking (minutes)	Slicing	Clean weight	Drying	Dry weight	WC % w/w		Mass loss on wet processing	Mass loss on drying
no	*g*	*type*	*minutes*	*quantity*	*g*	*days*	*g*	*BIO-1 measure*	*Oven method*	*%*	*%*
1	268	wet	50	all		3	30	13,6%	11,6%		89%
2	209	wet	0	some		3	14	*			93%
3	1010	wet	30	all	790	3	92	13,1%	11,0%	22%	91%
4	602	wet	40	all	480	2.5	82	13,5%	11,4%	20%	86%
5	280	dry	0	all		2.5	52	**	>20%		81%
6	858	wet	0	all		2.5	124	13,9%	11,9%		86%

* The size of the dried product was smaller than the minimum weight needed by the field moisture meter.

** The humidity measure on field was not possible as the moisture content of the product exceeded the detection limit of the moisture meter.

The moisture of the dried samples was measured using BIO-1[5], a portable moisture meter. The moisture measures were corrected afterwards following a standard humidity essay (drying oven method using a precision balance).

Once the product is boiled it loses some weight (see samples #3 and #4), but this initial lost of weight has no particular effect on the final moisture content. However, further testing should be done to confirm this.

Samples from 1 to 3 underwent 3 days of drying. The moisture content was acceptable by the end of the 3rd day of drying, so the process was stopped at that stage. Samples from 4 to 6 could only be monitored until noon during the 3rd day of drying. Only one of the samples was insufficiently dry. Several

[5] Manufacturer: Tanel Electronics & IT General Partnership

models of dryer were used at the same time to tackle the different drying batches, and every day the samples were moved from one dryer to the other. In the practice, the difference of results cannot be inferred to a particular model of dryer. Also, from samples #2 and #5, it could be inferred that the previous steps (dry cleaning and/or no cooking) influenced in the drying rhythm, but the data available from these experiences cannot confirm this hypothesis: on the contrary, sample #6 shows an uncooked sample that dried in only 2 days. Whether if the pre-treatment of the mushrooms is determinant to the drying speed should be confirmed through more experiences.

Average loss of mass after 3 days of drying (samples 1 to 3) is 91%.