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# REFLOR-CV – Adaptation of local communities to the impacts of climate change in Cabo Verde through restoration of wooded areas

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## Abstract

Cabo Verde (CV), a small island developing state, is one of the most vulnerable countries to the impacts of climate change, where drought and highly variable and concentrated rains constitute the main climate change threats. In this context, land degradation resulting from prolonged dry spells, surface runoff and erosion, and indiscriminate land use have been affecting land productivity, while shrinking native vegetation to *microrefugia* sites.

The project *Building Adaptive Capacity and Resilience of the Forestry Sector in Cabo Verde* (REFLOR-CV) focuses on the restoration of wooded and silvopastoral areas in three islands of the archipelago. The goal is to increase the resilience of local communities by promoting the conservation of habitats and biodiversity, favoring soil conservation and the replenishment of ground water, as well as supporting livelihoods through valorization of non-timber forest products. The project uses a knowledge-based approach that includes capacity building and the development of forest co-planning and co-management instruments, enabling participation and transparency in decision making.

For the development of island and stand level planning instruments, an agency approach is employed to ensure equity and accountability in the prioritization and implementation of nature-based solutions and restoration measures. During this process, locally preferable endemic, native or adapted woody species are produced in communitarian nurseries and in household orchards. Then, after a biophysical-climatic suitability of potential sites is technically analyzed and conveyed, community level decisions on site-specific land interventions are defined and implemented.

The results include ~ 800 ha planted in 40 patches and ~300 000 plants fixed, including 9 different native and endemic species. There are ~600 men and ~900 women directly involved in soil conservation and plantation activities, with ~50 technical staff capacitated. The calculation of the direct contribution of these results to the NDC of CV will be provided.

*Keywords: sustainable land use, co-management, endemic and native species, suitability analysis, governance*

## Introduction, scope, and main objectives

Cabo Verde (CV) is a Small Island Developing State (SIDS) located off the west coast of Africa as illustrated in Figure 1. It is one of the most vulnerable countries to the impacts of climate change, where drought and highly variable and concentrated rains constitute the main climate change threats (Correia et al. 2017). In this context, land degradation resulting from prolonged dry spells, surface runoff and erosion, and indiscriminate land use have been affecting land productivity, while shrinking native vegetation to *microrefugia* sites (Romeiras et al. 2016).

The strategy to strengthen the forestry sector requires climate change adaptation and mitigation options that meet the diversity of environmental conditions in the archipelago. Therefore, all situations must be addressed, from the semi-arid conditions of the geologically older islands whose relief does not favor scarce and irregular rainfall to the sub-humid conditions of the more recent islands whose mountains benefit more from rain and fog capable of sustaining more robust vegetation (Neto et al. 2020). This approach implies good species-site matching and good planting material of endemic species and design principles for reforesting the degraded landscape in the face of climate change. Also, special attention to the community's tenure and social and economic characteristics is necessary (Castilla-Beltran et al. 2021).

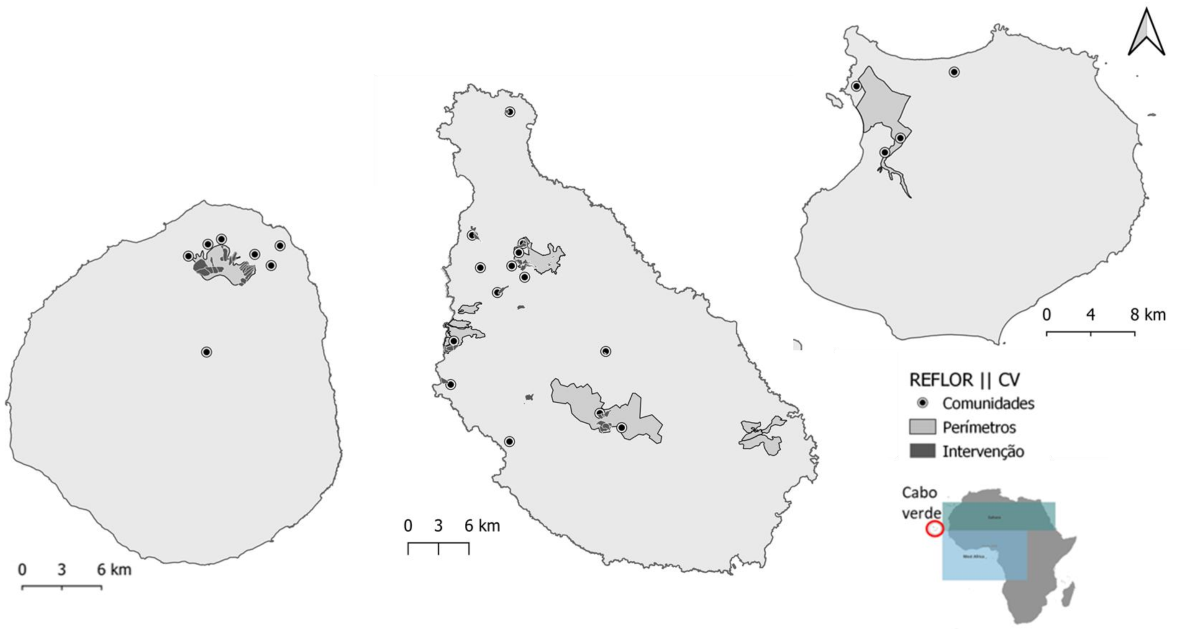


**Fig. 1:** Location of Cabo Verde and of the forest perimeters (Perímetros), intervention areas (Intervenção), and participating communities (Comunidades) in the three target islands. The light green and blue rectangles over Africa delimitate the closest subcontinental regions for climate projections under Representative Concentration Pathways: the Sahara and the West Africa subregions. From left to right: Santiago Island, Fogo Island, and Boa Vista Island.

A structured forestry intervention in Cape Verde considers three main environmental gradients. A first gradient would encompass the semi-arid islands, with shallow and extensive sandy beaches that make them in demand by the tourism sector. That is the case of Boa Vista, Sal, and Maio islands that denote consistent rural abandonment to varying degrees by competing with tourism investments and activities. In this case, the approach requires species that protect against sand encroachment but simultaneously generate income compatible with the demand by visitors, as is the case of certain fruit palms (Ribeiro et al. 2013, Lepp 2007). A second gradient considers the mountainous islands where the humidity allows family farming: Santiago, Santo

Antão, and São Nicolau. In this case, the forest must retain the water and soil on the ridge tops to regularize and smoothen the environmental conditions, although in certain cases, it allows a sustainable production of firewood (Tavares et al. 2014). Some species of the *Pinus*, *Cupressus*, and *Grevillea* genus have already proven their effectiveness. The volcanic circumstance of the island of Fogo allows considering a third gradient where the forest can, in addition to soil and water retention, prevent landslides, demanding the conservation of an exclusively protective forest, and less productive than the previous gradient.

REFLOR-CV includes one island of each of the three gradients - Santiago, Boa Vista, and Fogo - intending to introduce sustainable bases for the development of the forestry sector in the country (FAO 2017). From 2017 until 2021, FAO implemented this Ministry of Agriculture and Environment (MAA) of Cape Verde project, financed by the European Union. The project aims at developing regional and local forest management capacities and tools while installing ~800 hectares of climate-resilient and locally attractive forests and woodlands.

## Methodology/approach

### 1. Overall strategy

The strategy is organized around a landscape approach (Nielsen 2016, Sayer et al. 2013) aiming to maximize soil water retention through the expansion of woody native and endemic species in key locations. The success of this approach requires technically sound actions that are incentivized and sustained by the livelihood improvements they promote. For that, REFLOR-CV implements capacity development (Zoveda et al. 2020, Reij et al. 2020) at several organizational levels. Thus, within a continuous dialogue, the technical capacities of official staff are reinforced and at the same time, rural communities are empowered to progressively uptake adequate practices and benefits. Additionally, a wide-reaching awareness raising program is implemented, from schools to central governmental units. The following main steps are taken:

1. Development of an enabling environment with improvement of capacities at several levels, from local farmers to cross-sector central official staff and institutions;
2. Implementation of soil conservation, plant production, and plantation activities with the rural communities;
3. Analysis and support to the installment of local businesses and value-chains connected with plant production and forest products;
4. Awareness raising, technical support, co-learning, and advocacy to bring the forest sector into a higher political level by enhancing its role in the country's climate action.

In this context, the project supports the development of island and forest perimeter level planning and legal instruments using an agency approach (Zoveda et al. 2020, Reij et al. 2020). This ensures equity and accountability in the prioritization and implementation of ecosystem restoration measures.

### 2. Selection of intervention areas and community associations

The selection of soil and water conservation and plantation areas is performed through a collective assessment organized with the Ministry of Agriculture and Environment (MAA) through their local Delegations. These delegations work directly with the communities and are knowledgeable of the conditions and specificities of the areas under their supervision. At the same time, a technical assessment of the climatic and biophysical characteristics of potential sites is performed using traditional suitability analysis (Nielsen 2016) based on existing cartography (Diniz and Matos 1986, Diniz and Matos 1987, Diniz and Matos 1988, Rivas-Martinez et al. 2019), ancillary data (*Inventário Florestal Nacional de Cabo Verde*, 2012), and local expertise.

Several criteria are applied for the selection of sites, but a main concern is the inclusion of two bioclimatic areas: semi-arid and sub-humid in altitude. Then, since we are targeting upland situations where rainfed agriculture is practiced, areas within corresponding agroecological conditions, illustrated in Figure 2, were sought in the three islands.

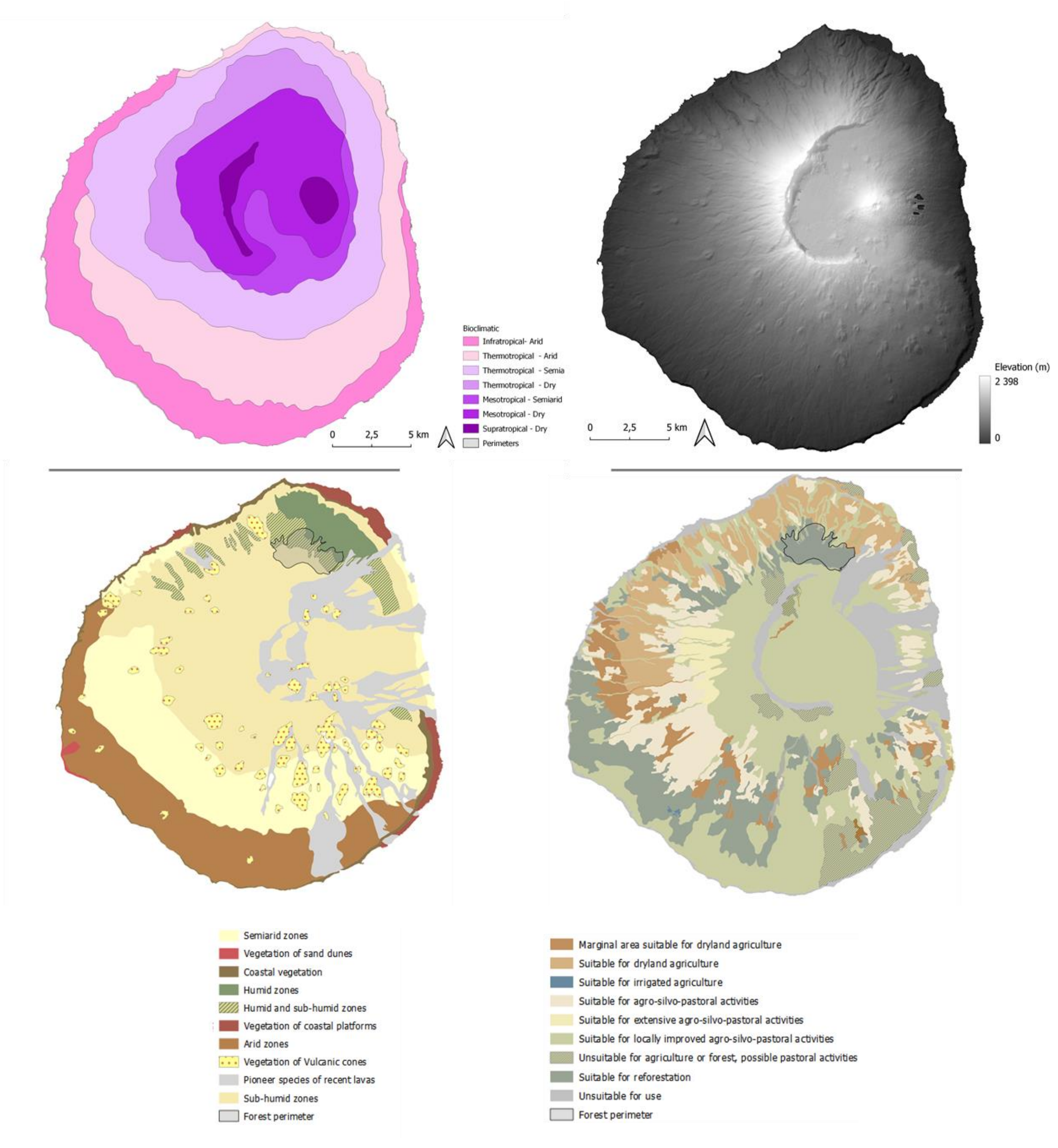


**Fig. 2:** Key-information used for suitability analysis. a) Bioclimatic map; b) Digital Terrain Model; c) Agroecological zones; d) Land use suitability. Example for the island of Fogo.

## 3. Implementation procedures

Based on a rank of potential areas, the best format for the participation of local communities was established. Thus, existing, or newly constituted communitarian associations were involved to receive capacity building and start collaborating. This entailed the compliance to a set of pre-established priorities guaranteeing inclusion of women, youth, and the elder (FAO, 2020). During this process, locally preferable endemic, native or adapted woody species are produced in communitarian nurseries and in household orchards.

Twenty-two selected associations received training in several relevant topics, such as Information and Communication Technologies (ICT), installation and management of nurseries, transformation of forest products, financial literacy, and business opportunities, as well as on soil preparation and plantation techniques. Figure 1 illustrates their areas of intervention and the location of the forest perimeters for which co-management plans were developed through a thorough participatory process. Figure 3 illustrates some of the local conditions and work.

**Figure 3:** Some of the local conditions and work. Photos from REFLOR-CV and MAA.

## 4. Monitoring and Verification

A wide set of capacities was provided to a multidisciplinary, cross-cutting set of official staff, from central to local levels. The capacity development focused on both field and office forest and woodland monitoring procedures and on the development of a digital platform for data input, storage, systematization, and management. REFLOR-CV delivered trainings on forest inventory, data organization and systematization, GIS, calculation of emission factors, surveying of biomass removals for energy, and quantification of land cover and land cover changes using *Open-Foris* and SEPAL (Open Foris 2021).

## Results

### 1. Technical and managerial achievements

The main managerial achievement is the significantly improved cross-cutting awareness of the role that wisely located forests, woodlands, and tree coverage in general play for livelihoods, sustainability, and climate resilience. Simultaneously, the positive experience of institutions with knowledge-based, multidisciplinary land use decisions and stakeholder participation ensures smoother implementation and the perpetuation of sustainability measures. Moreover, the products delivered during the project promote and facilitate Sustainable Forest Management (SFM). They are: participatory forest plans; new forest laws and regulations; four restored and functioning nurseries; a GenBank; a digital platform that hosts an Early Warning System for farmers, a WebGIS; and a database on land cover, forest perimeters and plantations as well as a public discussion *forum* on forest related topics. This *forum* can later be developed as a grievance mechanism, contributing to the environmental and social information requirements of performance-based claims.

The MAA is now better prepared for SFM and for developing a forest baseline, having gained abilities to perform a new forest inventory, calculating emission factors, and quantifying and reporting land cover changes. Likewise, the development of the EWS for farmers is facilitating a vertical interconnection between central institutions and local populations, especially the youth. This system, developed with the Institute of Meteorology and Geophysics (INMG) and hosted in the project's digital platform, is designed to provide advanced warnings of possible rains or high risks of flooding or forest fires through mobile phones. Such warnings assist decisions on plantation timing and provide guidance to rural practices, maximizing rainfed cropping successes and minimizing the risks to tree stands.

### 2. Community level achievements

The twenty-two associations involved in REFLOR-CV include twenty-six rural communities. Their members, together with technical official staff selected the fifty-one species to produce in the nurseries, including endemic, native, and introduced useful and previously experimented food and fodder species. Likewise, the communities selected the best plantation areas among eligible possibilities. Figure 1 illustrates the areas where the project intervenes, and Table 1 lists the species installed.
To ensure local uptake of the actions, some commercial plants are produced along with wild species. These mixtures already occur in agroforestry areas of the Santigo and Fogo and are adequate to increase the income available to local populations.

### 3. Forest and woodland areas

To support plant production, the project is promoting the construction of nurseries, while providing training for plant production in pre-existing functional nurseries. The plants included in Table 1 are those that, despite their main use, appear in wooded and agroforestry areas. However, other useful plant species, e.g. for tree orchards, are also produced in the nurseries. Table 2 provides an overview of the plant production and plantation results of the project so far. Furthermore, the project is contributing to the installation of a GenBank that, in addition to ensuring the conservation of local endemic and native species and varieties, will maintain species from the drier part of West Africa, such as the Sahel.

**Table 1**: Species selected for production in the nurseries. The species in bold are endemic species of Cabo Verde.

| # | Family | Taxon | Life form | Max Height (m) | Use |
|---|---|---|---|---|---|
| 13 | *Mimosaceae* | ***Faidherbia albida (syn. Acacia caboverdeana)*** | Tree | 20 | Soil conservation and fuelwood |
| 18 | *Fabaceae* | *Acacia holosericea* | Shrub | 3 | Food and fishing facility |
| 2 | *Fabaceae* | *Acacia victoriae* | Shrub | 6 | Shade and ornamental. Urban |
| 6 | *Malvaceae* | *Adansonia digitata* | Tree | 12 | Food |
| 5 | *Anacardiaceae* | *Anacardium occidentale* | Tree | 12 | Food and medicinal |
| 23 | *Asteraceae* | ***Artemisia Gorgonum*** | Shrub | 2 | Medicinal |
| 19 | *Moraceae* | *Artocarpus heterophyllus* | Tree | 6 | Food |
| 4 | *Amaranthaceae* | *Atriplex nummularia* | Shrub | 3 | Fodder |
| 7 | *Casuarinaceae* | *Casuarina equisetifolia L* | Tree | > 30 | Fuelwood and medicinal |
| 3 | *Fabaceae* | *Ceratonia siliqua* | Tree | 20 | Food |
| 10 | *Arecaceae* | *Cocos nucifera* | Tree | 30 | Food |
| 8 | *Cupressaceae* | *Cupressus sempervirens var sempervirens* | Tree | 35 | Ornamental |
| 9 | *Cupressaceae* | *Cupressus sempervirens var stricta* | Tree | 18 | Ornamental |
| 12 | *Asparagaceae* | ***Dracaena draco*** | Tree | 15 | Medicinal |
| 21 | *Boraginaceae* | ***Echium hypertropicum*** | Shrub | 2 | Medicinal |
| 20 | *Myrtaceae* | *Eugenia jambos* | Tree | 15 | Food and ornamental |
| 32 | *Euphorbiaceae* | ***Euphorbia tuckeana*** | Shrub | 3 | Medicinal |
| 14 | *Moraceae* | *Ficus benjamina* | Tree | 30 | Ornamental |
| 16 | *Moraceae* | *Ficus carica* | Shrub | 10 | Food and ornamental |
| 15 | *Moraceae* | *Ficus sycomorus* | Tree | 20 | Food |
| 17 | *Proteaceae* | *Grevillea robusta* | Tree | 35 | Soil conservation and fuelwood |
| 26 | *Plantaginaceae* | ***Grobularia amygdalifolia*** | Shrub | 2 | Medicinal |
| 22 | *Fabaceae* | *Leucaena leucocephala* | Shrub | 3 | Fodder and fuelwood |
| 24 | *Anacardiaceae* | *Mangifera indica* | Tree | 40 | Food |
| 1 | *Fabaceae* | *Parkinsonia aculeata* | Tree | 10 | Shade and ornamental |
| 28 | *Arecaceae* | ***Phoenix atlantica*** | Tree | 15 | Food |
| 29 | *Arecaceae* | *Phoenix dactylifera* | Tree | 25 | Food |
| 27 | *Pinaceae* | *Pinus canariensis* | Tree | 45 | Soil conservation and fuelwood |
| 11 | *Euphorbiaceae* | *Ricinus communis* | Shrub | 2 | Medicinal |
| 25 | *Sapotaceae* | ***Sideroxylon marmulano*** | Tree | 10 | Food and medicinal |
| 30 | *Fabaceae* | *Tamarindus indica* | Tree | 25 | Food |
| 31 | *Tamaricaceae* | *Tamarix senegalensis* | Shrub | 5 | Soil conservation |
| 33 | *Rhamnaceae* | *Ziziphus mauritiana* | Shrub | 2 | Food |

## 4. Main realizations of the REFLOR-CV project so far

Capacity development is the alma-matter of REFLOR-CV. Therefore, the main result of the project is the strengthening of the ability of institutions, organizations, communities, and individuals for climate resilient land use decisions and measures in the Agriculture, Forestry, and Other Land Use (AFOLU) sector of Cabo Verde. As such, the revision of strategic documents supporting the forest sector and the development of core capacities for the sustainable management of woodlands and forests, as well as of plant production and plantation capacities, are structuring results.

A participatory process continuously supports rural communities, official staff, and civil society organizations, including informal trainings and awareness raising. Moreover, formal workshops on climate change, agroforestry techniques for semi-arid and arid lands, gender issues, business development, ICT, and tending of nurseries, were delivered.

In addition to the areas with soil conservation measures and tree plantations, one key-result is the boost on capacities to monitor and verify the results of such activities. The update of the Nationally Determined Contribution (Ministério da Agricultura e Ambiente, 2021) took place during the development of REFLOR-CV. As such, the project assisted with knowledge to increase the contribution from the forest sector, improving transparency. For that, the document includes information on future tree plantation / afforestation possibilities as well as the needs of further assessing biomass removals from woodlands and forests. Additionally, an accounting of the carbon sink effect obtained through REFLOR-CV plantations is performed based on areas, species, number of plants, specific growth rates, and observed survival rates. Table 3 presents a preliminary simulation of the results, which after inclusion of the 2021 plantation figures, amount to a contribution of 2% to the current 2030 NDC target for all sectors (energy, transportation, and forestry) and to 11% if we consider the forest sector target alone.

**Table 2**: *D*ata on beneficiaries, areas of soil conservation measures, number of seedlings produced, and average survival rates. The numbers for 2021 and for the three beneficiary villages of the Boa Vista Island are not yet available.

| Island | Total Beneficiaries | | | 2018 | | | 2019 | | | 2020 | | | Average Survival Rate (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Restoration data | | | Restoration data | | | Restoration data | | | |
| | # of villages | # of men | # of women | Soil conservation areas (ha) | # Species | # Seedlings Produced | Soil conservation areas (ha) | # Species | # Seedlings Produced | Soil conservation areas (ha) | # Species | # Seedlings Produced | |
| **Santiago semiarid and arid** | 4 | 58 | 112 | 16.26 | 0 | 0 | 59.54 | 8 | 6300 | 25 | 10 | 18200 | 72% |
| **Santiago sub-humid and humid** | 12 | 152 | 416 | 59.23 | 14 | 21752 | 36.66 | 14 | 14622 | 52.91 | 26 | 40381 | 65% |
| **Fogo** | 7 | 227 | 206 | 44.51 | 8 | 6238 | 132.26 | 2 | 7771 | 224.09 | 11 | 10957 | t.b.d. |
| **Total** | **23** | **437** | **734** | **120** | **22** | **27990** | **228.46** | **24** | **28693** | **302** | **47** | **69538** | **69%** |

**Table 3:** The potential carbon sink effect of the REFLOR-CV plantations is shown in the first two white rows, with productivity calculated based on data from forest inventories of 2013 and 2020 in the Santa Catarina woodlands and Serra da Malagueta respectively. The subsequent rows are based on productivities observed in similar arid lands in Africa. The potential biomass accumulation reported in the NDC is also used. Productivity is expressed as average Aboveground Biomass (AGB) accumulation as obtained in the literature; Belowground biomass (BGB) accumulation is estimated with an average shoot to root ratio; CO2eqm corresponds to a calculation that takes survival / mortality rates into consideration.

| Type of forest | PER YEAR | | | | | | |
|---|---|---|---|---|---|---|---|
| | ton.ha-1.year-1 | | | Per REFLOR-CV area ton.year-1 | | | |
| | AGB | AGB +BGB | Carbon | Afforestation $CO_2$ eq | Reforestation $CO_2$ eq | Total $CO_2$ eq | Total $CO_2$ $eq_m$ |
| *Prosopis juliflora* \| Drylands | 0.58 | 0.82 | 0.34 | 590 | 796 | 1 386 | 970 |
| Mixed sub-humid forest\|Malagueta | 1.21 | 1.69 | 0.71 | 1 225 | 1 653 | 2 877 | 2 014 |
| *Acacia mollissima* | 2.85 | 3.99 | 1.68 | 2 884 | 3 893 | 6 778 | 4 744 |
| *Acacia albida* | 3.33 | 4.67 | 1.96 | 3 374 | 4 553 | 7 927 | 5 549 |
| Potential accumulation rate NDC | 4.36 | 6.10 | 2.56 | 4 413 | 5 956 | 10 368 | 7 258 |

## 5. Some good practices to share

The implementation of the project has been an opportunity to experience some good practices. Below we describe four selected practices:

**Environmental education at school**

The project has implemented environmental education sessions in classrooms of 10 primary schools, covering over 250 pupils and 50 teachers. Each session consisted of a theorical part (short lecture on the plants species in Cabo Verde, the environmental issues at global and country levels, and how to protect the environment) and a practical session (plantation of tree seedlings). The schoolchildren who benefited from the environmental session took responsibility for maintaining the planted seedlings. The teachers have been provided with a guide of environmental education and the local forest agent will keep technically supporting the school.

**Families involved in the Green Cities Initiative**

Praia, the capital city of Cabo Verde is one of the selected cities for FAO's Green Cities Initiative. The project has financially and technically supported the municipality of Praia in the implementation of plantation and development of a recreation area. Besides these activities, the project developed a plantation initiative involving the families of a district of Praia (Achada Grande da Frente). 100 families have been selected to receive 2 fruit tree seedlings per family. The seedlings are planted in the area under the control of the family, and children in the family are voluntarily engaged to protect, water, and take care of the seedlings. The objective of this initiative is triple: 1) contribute to the greening of the city; 2) motivate the local population to the GCI through the involvement of children, and 3) support the improvement of families' nutrition with fruits in the long term. The monitoring is under the responsibility of a local association that will yearly make a report to the municipality and continue increasing the number of families to receive seedlings, based on the funding that the municipality. The best performing families for 5 years may be rewarded by the municipality at the yearly ceremony.

**Communities' members capacitated in Information and Communication Technologies**

Many trainings sessions have been implemented for the benefit of the local communities' members in diverse subjects. The Information and Communication Technology capacitation is one of the most appreciated by the beneficiaries. The farms can now use the smartphone and computer to receive weather information to support their field activities. Using these facilities, they can more efficiently plan plantations and soil restoration activities.

**Installation of a GenBank with a focus on local species**

The project has developed a partnership between the National Agricultural Research Institute of Cabo Verde (INIDA), and the Word Agroforestry Center (ICRAF) to support the installation of a GenBank in the Santiago Island. The focus is on capacity building to allow the replication of the processes in other islands latter. INIDA has provided 1 ha of land for the installation of the GenBank and technicians to be trained for its management. In addition to the species locally collected, ICRAF has provided about 300 grafts and seedlings of 16 species and 39 kg of seeds of 15 dryland adapted species (namely the Sahel).

## Discussion and Conclusions

More than the high number of beneficiaries from the actions, the area intervened, or the number of plants produced, planted, and surviving, it is important to acknowledge the relevance of the rural communities' appropriation of SFM issues, tools, measures, and opportunities. Fieldwork managed by local organizations and new commercial chains promote local populations' ownership of woodlands and forest restoration activities. It increases the willingness of local communities to be involved in the co-management of existing plantations and tree stands. The co-management trend actively driven by REFLOR-CV, both nationally and locally, is further assisted by the project products. These products, along with the trainings on tools for monitoring and reporting, provide a strong incentive for continued data systematization with the digital platform used as a Monitoring and Verification System (MSV). Further development of this line of work can contribute to increase the effectiveness of forest management, transparency, and the capacity for international participation. Therefore, to incentivize such contributions, REFLOR-CV has been demonstrating the additional benefits of monitoring by producing draft estimates of the potential $CO_2$ mitigation effects of the plantations and of the corresponding possible payments. Such payments, even though pale when compared to those obtained by countries with rain forests, could be sufficient to ensure the costs of sustainability managing the planted woods and support improvements in local well-being.

Despite the satisfactory results of REFLOR-CV as measured by direct indicators, the boosting of SFM and conservation of tree stands in Cabo Verde entails the elevation of the forest sector profile by bringing it into a results-based climate financing path. The project activities have been co-creating such path by showing that SFM and afforestation activities can not only become socially up taken - increasing the country's resilience -, but also be monetized through international clean development funds. By combining the local and global benefits of afforestation and SFM in the UN decade of ecosystem restoration, the forest sector of Cabo Verde can become a key contributor to sustainability, income, and poverty alleviation.

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