



Leveraging the value chain-landscape governance nexus for non-wood forest products and tropical forest restoration

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ABSTRACT

The use and trade of non-wood forest products (NWFPs) may simultaneously bring about positive outcomes for conservation and rural development. This assumption underlies national strategies on NWFPs and Forest Landscape Restoration (FLR) in São Tomé and Príncipe. However, there is a lack of understanding of how native tree products such as *Adansonia digitata* (baobab), *Dacryodes edulis* (African plum) and *Treculia africana* (African breadfruit) are harvested, traded, and used. Besides, there is little knowledge about how both the landscapes these products originate from and the activities from harvest to consumption are governed. Using a value chain-landscape nexus approach, a quantitative survey with chain actors, semi-structured expert interviews and participant observations at marketplaces on São Tomé Island, we explored the socio-economic relevance of NWFPs included in FLR initiatives and how governance arrangements impact these. Despite being seasonal and limited to the capital, the formal trade of these products was of significant economic importance to the country. Nevertheless, weak statutory governance and an absence of customary governance arrangements puts the sustainability of NWFP harvesting, and thereby the outcomes of FLR, in jeopardy. The value chain-landscape governance nexus approach helps to understand how the use of NWFPs as part of forest restoration endeavors needs to take into consideration not only socio-economic benefits but also how the chains are governed in order to ensure that trade is compatible with FLR goals. Future research could further test the robustness of this conceptualization both in São Tomé and beyond.

1. Introduction

Currently, ecological restoration is high on the global environmental agenda (Wolff et al., 2018). It is estimated that global restoration commitments pledged under the Rio Conventions and the Bonn Challenge, combined with associated regional targets, may add up to 1 billion ha of land being restored by 2030 (van der Esch et al., 2022). With almost half of all restoration commitments, Sub-Saharan Africa is by far the most ambitious region (van der Esch et al., 2022). Despite being a Small Island Developing State, São Tomé and Príncipe (STP) in the Gulf of Guinea pledged to restore 32,000 ha of degraded and deforested landscapes by 2025, equal to about one third of the country's terrestrial surface (António, 2018). Mainly as a result of the colonial conversion of old-growth forests for agricultural production, only around a quarter of the native vegetation is left. The remainder is predominantly covered by agroforests or abandoned plantations that have turned into secondary forests (Dauby et al., 2022). These forested

systems, however, are increasingly degraded due to overexploitation for timber and other natural products (Dauby et al., 2022; Eyzaguirre, 1986). The Government's restoration aims are therefore instrumental for the continued provision of forest-derived goods and the conservation of the immense biodiversity on the islands, hosting one of the world's highest levels of endemism (Ceriaco et al., 2022a).

Forest Landscape Restoration (FLR) plays a key role in sustainably achieving such goals as it goes beyond just recovering ecological functionality by taking livelihoods of people into account (Besseau et al., 2018). As restoration commitments are operationalized, guidance is needed on practices that align with FLR and ensure sustained social-ecological restoration success (Brançalion and Holl, 2020; Brouwer et al., 2021). The enhancement of species that provide non-wood forest products (NWFPs), e.g., through enrichment planting, is seen as providing multifunctional forests that render both environmental and socio-economic benefits (Brançalion et al., 2012; Lamb, 2018). According to the Food and Agriculture Organization (FAO), NWFPs

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“consist of goods of biological origin other than wood, derived from forests, other wooded land and trees outside forests” (FAO 1999: 63).

Research has advocated but also cautioned on the difficulty of reaching dual win-win objectives of NWFPs for wellbeing and environmental gains (Kusters, 2008; Ingram, 2014). On the one hand, NWFPs generally attribute economic value to standing forests against the backdrop of increasing anthropogenic pressure. They can create a safety net against economic hardship (McSweeney, 2004; Shackleton and Shackleton, 2004) by contributing to food security and income diversification (Ingram et al., 2011; Sunderland et al., 2013), improve nutrition and health (Ahenkan and Boon, 2011) or yield benefits on a macro-economic level such as providing job opportunities in value-adding activities (Ingram, 2014). Besides, for many societies, NWFPs are also of high cultural importance (Cocks et al., 2011). Studies have evidenced that, as part of forest restoration programs, NWFPs can help meet such societal and economic expectations (Gasparinetti et al., 2022). Their use can safeguard these socio-economic and cultural qualities and support the conservation of overexploited and threatened species by creating sustainable value chains with positive implications for entire ecosystems (Chagas et al., 2021).

On the other hand, research has underlined that prudence is imperative when weighing the impact of NWFP utilization. Environmentally, their unsustainable exploitation may lead to a reduction in frugivore species (Moegenburg and Levey, 2002), cause soil degradation (Ramakrishnappa, 2002), facilitate influxes of invasive species (Cunningham, 1993), and, ultimately, drive forest degradation (Albers and Robinson, 2013). Especially the commercialization of NWFPs bears sustainability risks as it presupposes an abundant resource base (Meinhold and Darr, 2019). Actively restoring NWFP species could help to address some of these issues as it allows people to decouple their dependence on natural regeneration and thereby alleviate pressure on forests (Belcher, 2003). Nevertheless, pointedly fostering such species may evoke unintended modifications in ecological communities with possible environmental and socio-economic repercussions (Adams et al., 2016; Moegenburg and Levey, 2002).

The long-term success of NWFPs as an instrument to promote FLR is dependent on the socio-economic benefits they generate (Blay et al., 2008; Harrison et al., 2020; Lagneaux et al., 2021). Social and economic stimuli, in turn, directly link to factors such as market access, land tenure security, management and governance systems for resource use and FLR, and the selection of priority species (Ros-Tonen and Kusters, 2011; Wiersum et al., 2014). Consequently, understanding the actors and activities in FLR and NWFP trade, as well as the multiple, plural governance arrangements influencing them, provides a basis for assessing the socio-economic implications of NWFP valorization and generating sustainable, equitable outcomes (Ball and Brancalion, 2016; Ingram, 2014). Drawing on insights from other countries, leverages to create an enabling environment that facilitates sustainable NWFP value chains and FLR may include the revision and implementation of regulatory frameworks (Tieguhong et al., 2015), support of stakeholders with capacity building (Nguyen et al., 2020) and measures to upgrade NWFP production, processing, and trade (Mitchell et al., 2009). Through socio-economic incentives, value chains could contribute to overcoming the dependence of FLR on public resources, moving towards a production-driven restoration (Ha et al., 2022).

In STP, NWFPs feature prominently in governmental strategies such as the National Strategy and Action Plan for the Development of the NWFP Sector (ENPA-PFNL) from 2016 or the National Forest and Landscape Restoration Plan (PNRFP) from 2022, where they are envisaged to foster aforementioned benefits. Nevertheless, there has been little systematic investigation of NWFP value chains in STP, let alone their role in FLR. Such understanding, however, is a prerequisite for operationalizing associated governmental trade, development, and restoration agendas. Therefore, this study uses a value chain-landscape nexus approach to explore the socio-economic relevance of NWFPs included in FLR initiatives and how these are impacted by governance

arrangements.

2. Conceptual framework

A nexus approach to landscape and value chain governance provides the conceptual framework for this study.

2.1. Value chain governance

Advancing Porter's concept of value chains (Porter, 1985), Gereffi et al. (2001, 2005) shifted a focus to the agency of stakeholders managing production across spaces, how these stakeholders are socially and politically embedded, and how value is added to a product at different stages of the chain. Using a developmental lens (Helmsing and Vellema, 2011), value chains are understood as a series of value-generating activities constituting a pathway for resource(s) from an origin landscape via production, processing, and transportation to final consumption and, eventually, disposal (Gereffi et al., 2001; Kaplinsky and Morris, 2001). Value refers not only to the economic value of a product but also its intrinsic and extrinsic cultural, social, and environmental qualities (Ingram, 2014). A value chain implies that a product is commercialized in some way. The market where a commodity is traded may be physical or non-physical (e.g., internet) and include exchange for money or barter (van den Berg et al., 2013; Wiersum et al., 2014). Value chains can operate on local, national, or international levels. Consequently, stakeholders and activities along a value chain are subject to multiple governance arrangements, steering their performance and how costs, benefits and values are attributed to a product and embodied in the origin landscape.

Value chain governance refers to institutional mechanisms that affect the chain and through which a level of coordination of activities is achieved (Humphrey and Schmitz, 2001). Institutions may function as constraints or opportunities for stakeholders in the pursuit of their goals (Goodin, 1996; Ostrom, 1990) and influence what, how, where, when and how much of a good is traded (Humphrey and Schmitz, 2001). Such institutions - or governance arrangements - are set up and enforced by different, often plural governing bodies and include 1) formal state regulations and policies (Hopkins and Wallerstein, 1977, 1986), 2) market-based instruments (Cashore, 2002; Gereffi et al., 2005), 3) customary traditions, 4) project-based rules, 5) international agreements, and 6) corruption (Ingram, 2014; Ros-Tonen and Kusters, 2011). These mechanisms may govern some or all of the activities and stakeholders in a chain at different levels of vertical and horizontal separation of power. Some activities and stakeholders have little or no governing institutions or may have bricolaged governance whereby stakeholders craft hybrids and arrangements to suit them and gain maximum value (Cleaver and De Koning, 2015; Ingram et al., 2015). Together, these institutions create a multifarious and multilevel governance framework which directly and indirectly affects stakeholders and activities constituting a NWFP value chain. As diverse values and agency are generally held by different actors, this affects the equitable distribution of environmental and socio-economic impacts of different activities undertaken by value chain participants.

2.2. Landscape governance

Driven by global agendas around food security, climate change and biodiversity loss, researchers and policymakers have embraced landscape levels to develop scaled options that enhance ecological connectivity and sustainable land use (Sayer et al., 2013; van Oosten, 2013). Landscapes are conceptualized as “diverse geophysical/ spatial, social, environmental, and economical components on a mosaic of different land-use goals, multiple ecosystems, and functions in a determined time and space” (Pedroza-Arceo et al., 2022:3). As socio-ecological systems, they represent realistic units interconnecting objectives of sustainable development across geographic scales (Pedroza-Arceo et al., 2022) as

envisaged by FLR. FLR is understood as “a process to regain ecological integrity and enhance human well-being in deforested or degraded landscapes within biomes with a natural potential to support trees” (IUCN, 2015a: n.p.). Scales in FLR do not necessarily correspond with administrative units, and the concept implies balancing ecological and socio-economic objectives and the interests of multiple stakeholders (Mansourian, 2017; van Oosten et al., 2014). Stakeholders’ rights and responsibilities need to be clarified and competing claims may require negotiation (Sayer et al., 2013). As FLR is a long-term process, these aspects need to be considered over time (Reed et al., 2020). Interests may change as the value of (restored) landscapes and the products originating from them also change. Landscape governance helps to understand the plural institutional mechanisms governing land, forests, and their restoration, how they hinder or support restoration efforts and how obstacles may be mitigated (Mansourian, 2017). This is crucial as governance issues are a major challenge to successful implementation of landscape approaches such as FLR (Sayer et al., 2013).

2.3. Value chain-landscape governance nexus for NWFPs and FLR

Combining the two concepts provides traction to understand how the production and trade of NWFPs with their associated qualities,

quantities and geographies is governed in STP as well as how different actors and activities affect the value chains’ performance. It also sheds light on the role NWFPs play in forest restoration to render positive social, economic, and environmental outcomes.

Restoration in STP is pursued on a landscape level and operationalized in the PNRF by stipulating three reference landscapes in which specific measures are planned. Consequently, the interplay between NWFPs and FLR requires using a nexus approach to governance. The concept of landscape governance explicitly harnesses the multi-levelled actors, activities and arrangements affecting the resource node of a value chain used to meet FLR goals. Consequently, using NWFPs in forest restoration to enhance the resource base for socio-economically profitable value chains as conceptualized in the PNRF requires considering all governance structures influencing decision-making. Given that ecological and institutional phenomena interact across different vertical, horizontal, and temporal scales, deploying a multi-level approach offers a wider perspective and avoids overlooking critical features (Ingram et al., 2014; Ros-Tonen et al., 2015). A small-island state like STP where NWFPs are envisaged to play an important role in FLR efforts allows to apply this conceptual framework in a relevant but spatially confined system. This framework is illustrated in Fig. 1.

The value chain-landscape governance nexus framework informed

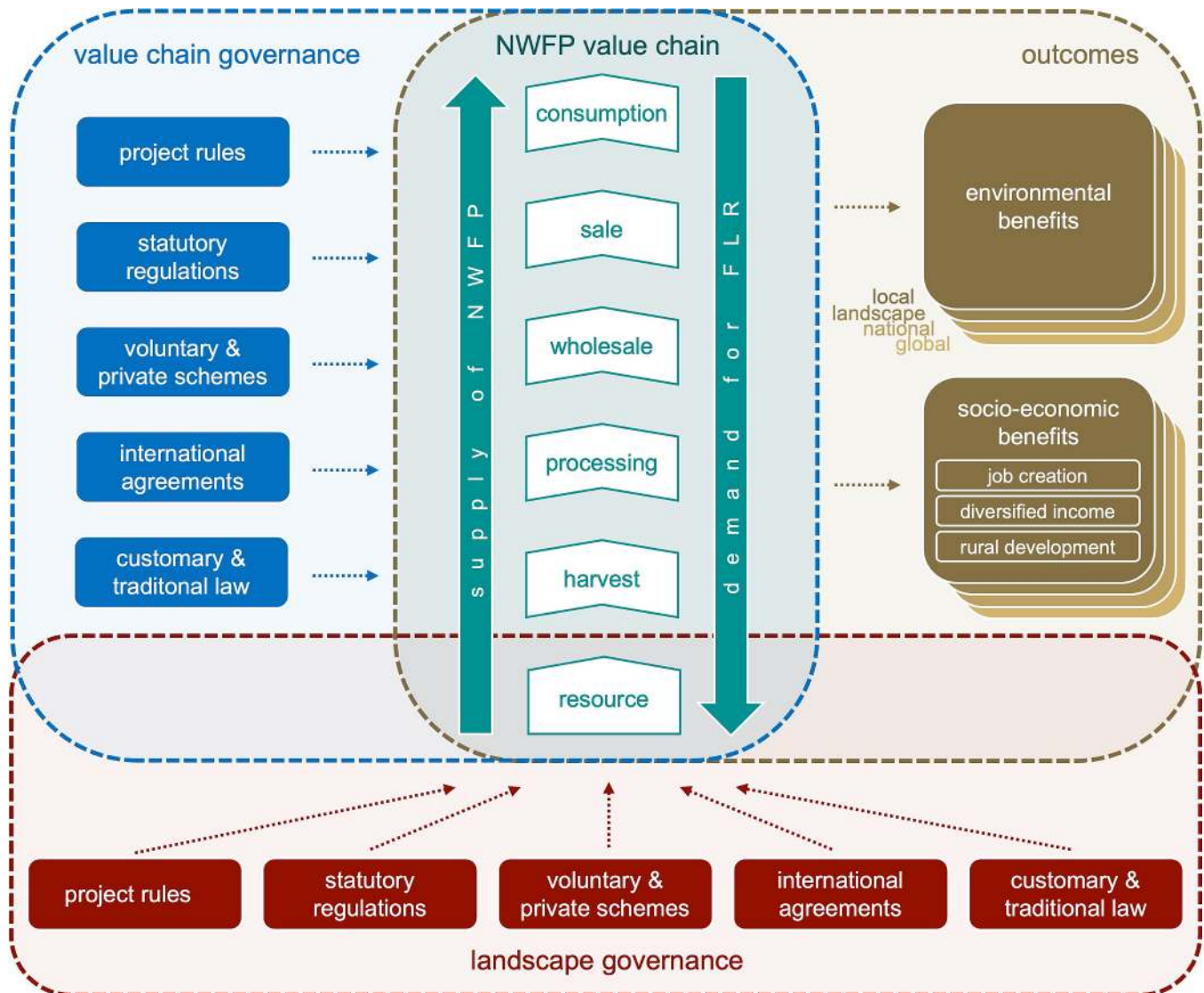


Fig. 1. Value chain-landscape governance nexus to interpret NWFP in landscape restoration. (Source: own illustration based on Ingram (2014) and Mansourian (2017))

data collection and analysis from which we drew variables (Table 1) that guided the process of delineating, clustering, and engaging with different bodies of knowledge to address the research objective, and provided a lens to organize and systematically interpret the collected data.

To operationalize the two governance frameworks, the multi-scale institutional mechanisms of landscape governance were assimilated and linked to restoration activities, actors, practices, values and processes. We used value chain analyses (VCA) to understand NWFP value chains and to map and categorize the economic, social, and environmental processes (Kaplinsky and Morris, 2001). A VCA sheds light on how actors are linked, coordinated, and positioned in the chain (Gereffi and Fernandez-Stark, 2016; van den Berg et al., 2013). VCA also enables an exploration of the origins, destinations and flows of information and goods, their volumes, and values as well as the distribution of power in terms of costs and benefits (Kaplinsky and Morris, 2001; Liu et al., 2014; Hermans et al., 2023). This allows to determine a chain's socio-economic relevance regarding the creation of jobs and diversified income, food security, rural development, or gender equality. The VCA was inspired by the analytical procedure suggested by M4P (2008) but was tailored to the restoration and developmental context to illuminate the nexus and to identify challenges during production and trade (Humphrey and Schmitz, 2001). The variables underpinning the VCA with their interlinkages are shown in Table 1.

3. Methodology

3.1. Study area

The study area (Fig. 2) is constituted by São Tomé, an island with oceanic equatorial climate (Ceriaco et al., 2022b). Covering around 26.5 % of the island, the tropical forest remnants in the southwest

correspond largely with the core area of Obô National Park. Succession in areas of agricultural abandonment following independence in 1975 created secondary forests located mostly in the buffer area around the park, amounting to roughly 30.5 %. The rest of the island is characterized by agroforestry systems geared towards cocoa and coffee (28.5 %), and non-forested land (14.5 %) including dwelling areas and savannahs in the northwest that host a small exclave of the national park (Dauby et al., 2022; Soares et al., 2020).

Classified as a globally outstanding ecoregion of biodiversity, STP is the only country that lies entirely in the Guinean Forests of West Africa hotspot (Burgess et al., 2004; IUCN, 2015b; Myers et al., 2000). As forest biodiversity is mostly threatened by overexploitation (Lima et al., 2022), studying the factors related to human pressure on the ecosystem is of particular interest. In STP, 225,000 inhabitants, or 96 % of the country's population, live on the main island (INE, 2015; World Bank, 2023a). 76 % of Santomeans live in urban centers (World Bank, 2023b) and the capital district Água Grande is the most populated area, hosting 39 % of all inhabitants (INE, 2015).

The Restoration Initiative (TRI), a collaboration between the Directorate of Forests and Biodiversity (DFB), the International Union for Conservation of Nature (IUCN), the United Nations Environment Programme (UNEP), and FAO, has promoted forest restoration and sustainable NWFP utilization across the island since 2018. It aims at restoring 12,000 ha of tropical forest landscapes by 2024, with 3200 ha restored by the end of 2022 (IUCN et al., 2023). Another associated project, Tesouros d'Obô, is implemented by the University of Coimbra and DFB and supports sustainable agroforestry in four communities. Other organizations active in the wider field of sustainable forest utilization are OIKOS and BirdLife International which, together with local partners such as Associação Monte Pico, have implemented related activities, partially within EU-financed projects (Sánchez, 2020; ECOFAC, 2024).

Table 1

Underlying variables of the value chain-landscape governance nexus framework with associated data collection methods

#	Variables	Explanation and interlinkage of variables	Data collection methods			
			Qualitative data		Quantitative data	
			Expert interview	Literature review	Participant observation	Survey
1	Relevant NWFPs	Identification of NWFPs relevant for analysis	X	X		
2	Core processes	Processes/ nodes/ stages that constitute both the pathway of value addition of the NWFPs from production to consumption and FLR	X	X		
3	Main actors	Types of actors that are engaged or involved in the core value chain and restoration processes	X	X	X	X
4	Main practices	Types of practices performed by actors as part of the value addition and restoration process	X	X	X	
5	Flow of products	Transformation of the NWFP from raw material to final product based on practices		X		X
6	Flow of information	Information sharing among main actors regarding product requirements, restoration needs etc.		X		X
7	Product volumes & number of actors	Quantification of actors and volumes of NWFPs traded	X	X	X	X
8	Geographical flow of products	Mapping of the different core trade processes and their geographical patterns	X	X		X
9	Seasonality of NWFPs	Identification of temporal patterns in production and trade of NWFPs throughout the year	X	X	X	X
10	Economic, social and cultural values	Quantification of economic values and identification of social and cultural relevance of NWFPs, the landscape and its restoration	X	X	X	X
11	Actor relationships	(Non-)contractual relationships between the different actors engaged in value chains and FLR	X	X		
12	Auxiliary services	Potential services feeding into processes the value chain or into FLR, such as training, certification, finance, exportation, importation	X	X	X	
13	Stakeholders	Individual, private, civil society or public entities that are interested in, benefit from, influence and/or are affected by the value chains or FLR	X	X		
14	Institutional mechanisms	Governance frameworks that affect the value chains and FLR, including statutory, private, project-based, international agreements-based and customary governance mechanisms	X	X	X	
15	Challenges	Identification of challenges perceived by value chain and FLR actors and stakeholders	X	X	X	X

Source: adapted from M4P (2008), Ingram (2014) and Mansourian (2017).



Fig. 2. Harvesting areas for *A. digitata*, *D. edulis* and *T. africana* on São Tomé. (Source: own illustration based on shapefiles from DFB (2020).)

3.2. Value chain selection

Given STP's wealth in NWFPs, a selection of value chains was made. In absence of scholarly work, this was guided by PNFRP and ENPA-PFNL, two governmental policies stating priority NWFP species presumed to render positive environmental and socio-economic effects. Three species, *Adansonia digitata*, *Dacryodes edulis* and *Treculia africana*, were selected in consultation with DFB and FAO, considering seasonality, existing markets, and indigeneity to STP.

A. digitata is a native tree found in the savannah in the north of São Tomé, where it is believed to have arrived naturally via sea dispersal from the mainland (POWO, 2023a; Tsy et al., 2009). Known internationally as baobab and locally as *imbondeiro*, the tree produces ovoid, pendulous, hard-shell fruit called *micondó*, reaching 12 cm and over (du Preez, 2003). Besides the edible white-orange powdery water-soluble pulp, seeds, leaves, and bark are processed for medicinal, nutritional, and cosmetic purposes (Orwa et al., 2009a).

D. edulis, also known as African plum, is a forest tree native to tropical Africa, including STP (POWO, 2023b). The Portuguese vernacular name *safuzeiro* derives from its ellipsoidal, up to 12 cm long, violet drupes with edible pulp (Orwa et al., 2009b) referred to as *safú* locally. Although *safú* is the main plant product, also the bark can be harvested for medicinal use (Anegebe et al., 2005; Ajibesin, 2011).

T. africana, known as African breadfruit or *izaquenteiro* in STP, is a cauliflorous forest tree that produces a massive fruit reaching 40 cm and 14 kg (Ojmelukwe and Ugwuona, 2021). Also native to Africa's tropical forests (POWO, 2023c), it is appreciated for its nutritious seeds embedded in a spongy pulp. The seeds are called *izaquente* in STP and used in various dishes (Orwa et al., 2009c).

3.3. Data collection

A multi-method approach that adhered to the ethical principles of the Netherlands Code of Conduct for Research Integrity allowed for triangulated quantitative and qualitative data collection (following Turner and Turner, 2009) based on variables (see Table 1) drawn from the conceptual framework. Literature review was conducted to examine the governance framework and value chains. Given the scarcity of associated scientific publications, gray literature was harnessed to reconstruct institutional frameworks. We scanned all Santomean government gazettes (*Diário da República*) published by the General Assembly until April 2023 for legislation associated with the research topic. We studied 18 legislative enactments deemed relevant for this study in depth. In addition, we analyzed 12 related governmental strategies and six international agreements that we identified through consultation with FAO and DFB, and subsequent snowball search (see S1).

Participant observation served as the starting point for in-field data collection in May and June 2023 to identify actors and their practices and to map the chains. According to Bernard (2018: 276), participating observers are “outsiders who participate in some aspects of life around them and record what they can.” Guided by a memorandum (S2), this role included observations of chain participants, values and activities with geolocations and times in the island's main market, in all six district markets, five supermarkets, three souvenir shop and two informal locations specifically known for the products. DFB and FAO were consulted to select sites for participant observations, covering the most frequented trade points of the island. Besides, production and processing sites for all three value chains were visited. Field notes were made to document the information from the observations.

Once chain actors had been identified, purposive sampling was deployed to select participants for quantitative and qualitative interviews. The participants of the two methods were mutually exclusive. After informed consent was granted, a questionnaire (see S3) guided interviews with 41 value chain participants, capturing information on environmental, social, cultural, and economic dimensions of the selected chains, including aspects of the preceding chain node. Data collection for the survey was supported by two field assistants with local expertise. Based on interview guides (see S4), a further 24 semi-structured interviews were held with informants (see S5) possessing expert knowledge on the chains or FLR to provide associated qualitative data. Identified subsequently by snowball sampling, informants included representatives from ministries, private sector, development agencies, and civil society. All interviews were conducted in Portuguese and in person except for two semi-structured interviews that were held in English and online. On average, the semi-structured interviews took 26 minutes.

In the absence of references from STP and given the geographic and seasonal variations across the distribution ranges of the species, literature provided regional benchmarks of tree productivity. A mature *A. digitata* tree may yield 80 kg of fruit annually (Habte and Krawinkel, 2018), *D. edulis* 200 kg of safú (Omoti and Okiy, 1986) and *T. africana* 160 kg of izaquente (Orwa et al., 2009c). These figures were multiplied by the harvesters' average revenue per kg based on the survey to generate an estimation of profitability per tree.

3.4. Data analysis

The recorded semi-structured interviews were transcribed using intelligent verbatim with codes based on the conceptual framework (Table 2) and were analyzed with Taguette (Rampin and Rampin, 2021) to synthesize qualitative information. To ensure confidentiality, the names of interviewees and businesses were anonymized. Quantitative data from interviews was transferred to an MS Excel spreadsheet and analyzed using descriptive statistics with profits calculated based on participants' estimations of total costs and incomes for the preceding

Table 2

Codes used for qualitative data analysis.

#	Category	Codes ^a	Type of code
1	Value chain nodes	Forms of consumption	I
2		Activities	I
3		Characterization of actors	I
4		Seasonality	D
5	Value chain geographies	Resource base	I
6		Harvesting sites	I
7		Processing sites	I
8		Vending sites	I
9	Values/ benefits of NWFPs	Economic values	I
10		Environmental values	I
11		Social values	I
12		Cultural values	I
13	Governance	Statutory regulations (value chain)	I
14		Statutory regulations (FLR)	I
15		Customary law (value chain)	I
16		Private schemes (value chain)	I
17	Challenges	Private schemes (FLR)	I
18		Project rules (value chain)	I
19		Project rules (FLR)	I
20		International agreements (value chain)	I
21		International agreements (FLR)	I
22		Effectiveness of governance arrangements	I
23		Sustainability	D
24		Perishability of NWFPs	D
25		Bureaucratic constraints	D
26		Entry requirements	I

^a Sub-codes included a differentiation for each value chain; I = inductive from conceptual & analytical framework; D = deductive from qualitative interviews.

time period and extrapolated to a year. Conversion rates for units sold, volumes, economic values, and profits were calculated following Ingram (2014). Formulas for all calculations can be found in the supplementary material (S6). Spatial data and shapefiles from DFB (2020) were harnessed to map geographies of chain activities (see Fig. 2) using QGIS (v.3.28.8).

4. Results

4.1. Governance frameworks

4.1.1. Governance through international agreements

Although STP is a signatory to multilateral environmental agreements on biodiversity, these conventions do not specifically govern the selected NWFPs (CBD, 2023a, 2023b; CITES, 2023a, 2023b). Similarly, the IUCN Red List of Threatened Species as a governance tool sees no particular risk for the three species (Borokini and Hills, 2021; POWO, 2023a) and directives from the Central African Forest Commission to increase the entrenchment of NWFPs in national laws have not been implemented due to a lack of authoritative ownership and capacities (COMIFAC, 2008).

STP pledged to restore 32,000 ha by 2025 under the Land Degradation Neutrality (LDN) goal of the United Nations Convention to Combat Desertification (UNCCD, 2023). The coordination of LDN objectives lies with DFB and the 12,000-ha target of TRI is a translation of this commitment into practice.

4.1.2. Project governance

TRI developed the PNRFP as the official FLR strategy in STP. It identifies landscape-specific restoration objectives for different land use systems, provides cost estimates, and names priority species for restoration based on their ecological importance, vulnerability, and utility for wood and non-wood products. The project implements the PNRFP accordingly in three priority landscapes on the island using both assisted natural regeneration and enrichment planting (IUCN et al., 2023). For

that, seedlings of all three species are produced in nurseries according to quantitative targets, available space, and planting density. The PNRFP proposes *A. digitata* for the savannah ecosystem where restoration aims to prevent fires and satisfy the local community's resource needs. *D. edulis* and *T. africana* are regarded as priority species in diversifying agroforestry systems to improve soil fertility and plots' productivity regarding timber and non-timber forest products (DFB, 2022).

The Tesouros d'Obô project attempted to establish a community forest within the harvesting area of *A. digitata*, enabling people living with access to the resource to make economic use of it without compromising environmental vitality. However, the endeavor was aborted due to high levels of baobab harvest by an external group of harvesters which could not be legally restrained from harvesting, leaving the community with insufficient material to trade. While other organizations partially focused also on NWFPs, particularly those requiring immediate conservation action such as the endangered endemic Obô Giant Snail (Panisi et al., 2020) or wild honey (Nascimento, 2015), none included the three selected VCs.

4.1.3. Statutory governance

Legislative provisions are embedded in the forestry, environment, land tenure and trade domains. The only environmental legislation that specifically considers NWFPs and restoration is the Forestry Law (Law N°05/2001). It stipulates generic mechanisms for sustainable silviculture and mandates DFB for its enforcement. DFB's competencies include developing forest plans that prescribe the areas, extent, and aims of forest restoration and the coordination of corresponding actions for breeding, planting, and maintaining saplings. Hereby, forest restoration encompasses explicitly also NWFPs. However, while the law provides the cornerstones for resource restoration and management, a statutory instrument specifically regulating the harvest and trade of NWFPs, e.g., through user right allocation, does not exist. DFB faces financial constraints that translate into limited effectiveness in monitoring and enforcement of the legislation. As a result, the last forest inventory was conducted in 1999 and did not aggregate data on a species level.

The environmental regulations are complemented by land legislation. The plantation system originating from the Portuguese colonial rule was nationalized after independence and replaced by a network of state-owned agricultural enterprises (Eyzaguirre, 1989; Seibert, 2016). Following the agrarian reform in the early 1990s (Muñoz-Torrent et al., 2022), Decree N°32/88 makes provision for a diversification of land use systems, with over two thirds of previous plantation area being parceled and distributed through long-term usufruct concessions to smallholders. Even though the constitution acknowledges private property, rural land is predominantly owned by the state through concessions (Horta and Pardo, 2019; Seibert, 2006). Albeit rarely enforced, the decree entitles the state to revoke any concession if it deems the respective land use as inappropriate (Seibert, 2006). The harvest of agricultural and silvicultural products from someone else's concession plot entails severe penal consequences. However, while people follow the law during the day, frequent illegal harvesting at night was reported.

Obô National Park is enacted by Law N°06/2016 that aims at preserving the island's habitats and provides for the demarcation and zonation of the park. This includes core conservation areas in which activities implicating human disturbances other than research and ecotourism, such as NWFP harvesting, are prohibited, as well as buffer zones. These buffers, in which moderate land use is permitted if it does not change the natural ecosystem, are envisaged as transition zones between the core area and the surrounding cultivated land. However, by not defining buffer zone boundaries and factually retracting the prohibition of activities irrespective of the zonal classification in subsequent paragraphs, the law is not effective in inhibiting the extraction of NWFPs (Lima et al., 2022).

There is no national trade legislation addressing NWFPs specifically. Import and export of plant-based material requires phytosanitary inspection before shipping according to Decree N°5/2016 which

practically affects only the export of baobab seed oil. Regarding domestic trade, generic regulations such as Law N°14/2007 on workplace hygiene and safety demand minimum standards for processing enterprises. Legally, commercial trade is restricted to designated trading venues such as supermarkets, shops, and district markets by Decree N°7/2004. In the latter, as market products are not taxed otherwise, every vendor is obliged to pay stall fees to a municipal market master.

Besides laws, the only government strategy specifically on NWFPs, ENPA-PFNL, was launched 2016 by DFB. The policy identifies 26 priority NWFPs based on their socio-economic potential and presents an action plan to improve incomes for chain participants, enforcing the regulatory framework and its integration into political and economic planning. While some parts of the strategy were implemented, a general lack of institutional ownership left many action points unimplemented. A second policy indirectly touching upon NWFPs is PNRFP (see [Section 4.1.2](#)).

4.1.4. Voluntary governance

Voluntary and market-based governance arrangements for NWFPs and restoration in STP are limited. No forest certification body or any payments for ecosystem services schemes exist that guide the extraction of NWFPs or their restoration. Cooperatives have volunteered to participate in FLR efforts coordinated by TRI. Both the cocoa and coffee cooperatives support the project in implementing restoration activities. Already before the project, the cooperatives were involved in forest restoration given the importance of shade tree species in cultivation. Based on needs assessments among members, seedlings of multiple species, including *D. edulis* and *T. africana*, are grown in cooperative-owned nurseries and provided to members that want to enhance agroforestry species composition.

4.1.5. Customary governance

Given that the islands were uninhabited prior to the Portuguese arrival in 1471, the societal composition and its cultural imprint is a direct result of colonial history. Despite being a small state in size and population, STP has a high diversity regarding the geographic origin of its citizens with roots in nowadays Benin, DRC, Angola, Mozambique, and Portugal. However, despite partially sharing beliefs, habits, and traditional knowledge cross-culturally, the inhabitants of African origin could not maintain or re-establish social, religious, institutional, and economic structures on STP as political power was monopolized by the Portuguese (Seibert, 2015). Although STP gained independence in 1975, the long-lasting assimilation to Portuguese culture and norms has visible ramifications, including the way natural resources are governed. Since neither a traditional authority nor an associated rule system exist, there are no customary approaches, such as spiritual or sacred natural sites, that govern the extraction or restoration of NWFPs. On the contrary, interviews indicated prevailing beliefs that the land belongs to all Santomeans and thus can be accessed and utilized by any local indiscriminately.

4.2. Status of the value chains

4.2.1. Actors and practices

In the baobab chain, a group of men, aged on average 25.5 years, are the main actors ([Table 3](#)) that, as individuals, act as harvesters, transporters, and vendors of the raw fruit. They generally collect baobab from the ground, but, with an uptake in market demand, have started to cut it unripe from the tree (field notes, 10-05-2023). Afterwards they transport the fruit to a vending site in the capital for sale where it is their only commodity traded. Besides individuals, customers include small businesses that either dry the fruit's pulp or process it into juice and ice pops. One enterprise purchases residual seeds from juice production to extract cosmetic oil. Processors prefer mature, large, and reddish-brown fruits as they generate better yields of the final products.

Ripe safú is collected from the ground, either after it drops naturally

Table 3

Characterization of vendors and trade at marketplaces.

	<i>A. digitata</i> (fruit)	<i>D. edulis</i> (fruit)	<i>T. africana</i> (seeds)
<i>Characterization of vendors</i>			
Mean age in years (SD)	25.5 (2.0)	43.5 (13.0)	34.3 (17.1)
Number of vendors	9	34	10
Gender	100 % male	100 % female	90 % female 10% male
NWFP self-harvested	100 %	4 %	90 %
Vendors sold only one NWFP	100 %	41 %	40 %
<i>Estimated trade</i>			
Vendor's mean profit per day (SD)	US\$23.91 (6.21)	US\$4.32 ^a (1.52)	US\$21.54 ^a (12.10)
Total annual volume sold (all vendors)	36.4 t	97.2 t	19.0 t
Total annual amount sold (all vendors)	US\$34,630	US\$209,569	US\$26,769

^a Values in Mercado de Bobo Forro. Exchange rate: US\$1 = Db22.46 (calculated using the average of the first and the last day of field work).

or after trees are shaken (field notes, 07-05-2023). Particularly in rural areas, safú is often sold informally directly to consumers or to vendors ([Table 3](#)) in bulk at farm gate. Most safú vendors neither harvested the fruit themselves nor specialized in the product. While the fruit is generally sold unprocessed, one processor produces dried pulp, and one extracts cosmetic seed oil.

Izaquente vendors usually harvest and also process the fruit. The seeds require lengthy processing procedures to become marketable: After the ripe fruit fell off the tree, it is left fermenting for a week before the decayed pulp is washed off and the seed coat is separated from the edible endosperm. Hulling is done through boiling and subsequent crushing of the seeds with a stone ball (field notes, 14-05-2023). As the seeds are highly germinative, they are usually either sold directly or offered on demand. To increase shelf life, one business purchases fresh seeds directly from processors and sun dries them.

4.2.2. Resource, geographies and seasonality of trade

The distribution of *A. digitata* is confined to the savannah along the Northern coastland, particularly between Neves and Guadalupe, with reports of some specimens further inland. Although it also grows on private plots, the fruit traded in town is harvested only on state land from wild specimens, especially around Obô National Park and Neves ([Fig. 2](#)). *D. edulis* and *T. africana* are abundant in forested areas throughout the island with a predominance in Mé-Zóchi district. They grow spontaneously in- and outside the park on state land but are also cultivated on agricultural parcels and private land. The harvesting area for safú and izaquente traded in the capital district Água Grande lies around Trindade.

Água Grande accounts for most formal sales with little trade happening within the harvesting regions. People in rural areas tend to cater for their needs by collecting NWFPs from around their homesteads or trading them informally with neighbors. In the capital São Tomé, sales are highly centralized. All baobab vendors sell at a central cross-roads in the capital or around the old Mercado Municipal (field notes, 08-05-2023). Safú and izaquente are sold also mainly at Mercado Municipal or at the country's biggest marketplace, Mercado de Bobo Forro. 8 % of safú vendors sold outside Água Grande at municipal markets in Guadalupe and Neves.

Market trade is strongly aligned to harvesting seasons with a peak between March and June ([Table 4](#)). To a lesser extent, baobab and izaquente are also sold in other months.

Except baobab ice pops, usually sold for direct consumption in crowded places around the city center, processed products like dried pulp, dried seeds, and seed oils, were sold only in supermarkets and souvenir shops in the capital. As the sole product going into foreign trade, baobab seed oil is exported to Europe and the Middle East on a

Table 4
Number of vendors per month at main marketplaces.

	January	February	March	April	May	June	July	August	September	October	November	December
Baobab	1	2	6	6	7	8	5	2	1	1	1	1
Safú	10	11	12	14	13	8	1	0	0	1	1	8
Izaquente	3	3	5	7	7	3	3	3	3	3	3	3

Source: research results (survey).

Numbers refer to the number of responses in the questionnaires and are reflected in the colors individually per product on a scale from low (white) to medium (yellow) to high (red).

small scale.

4.2.3. Economic values

The breakdown of profits (Fig. 3) shows how different chain actors benefit from their participation in the chains. Although monetary profits differ significantly between the NWFPs, the distribution of profits among different chain nodes was similar for all three products. Generally, the share of harvesters and vendors was the largest, followed by transportation and municipality levies.

Whilst recognizing differences in individual trade volumes and seasonality of harvests, these figures can be extrapolated to annual values. The trade volumes and values of the three NWFPs sold in marketplaces (Table 3) show the differences between the value chains, with safú being the most traded product by volume and value. Extrapolating these figures by using regional benchmarks from literature, once reached its maturity, a single planted *A. digitata* tree may generate an annual revenue for harvesters worth US\$75.89 for unprocessed fruit, *D. edulis* US\$250.81 for raw safú, and *T. africana* US\$374.98 for izaquente.

4.2.4. Challenges

The interviewed experts saw the chains confronted with several challenges. The small distribution range of *A. digitata* is affected by regional development and global climate change. The area is a popular tourist region where construction works sacrificed trees. Also, the species' distribution along the coast was seen as a threat, as many specimens are located on the shore and could fall victim to a rise in sea level due to global warming. Tree populations are affected directly by the use of their wood for fuel and timber. Although professional lumberjacks consider the utility of the species for construction and energy generation as marginal, incidents of illegal logging were reported. Besides, unsustainable harvesting practices of *D. edulis* bark are a threat to the survival of the exploited trees.

T. africana is not very popular among farmers participating in restoration activities as the workload to process seeds is high but not reflected in the price. Also, considering their big size, falling fruits are associated with injuries and, finally, people do not see the necessity to plant *T. africana* as wild trees exceed the current demand.

Safú was reported by chain participants to face occasional low demand, leading to high rates of auto-consumption by vendors and negative effects on their income. This is exacerbated by the fruit's perishability requiring prompt marketization after harvesting.

Premature and extensive collection of baobabs by harvesters "from outside" the communities living with the resource was indicated to lead to insufficient baobab for community members to commercialize the fruit themselves.

5. Discussion

5.1. Social and economic significance of NWFPs

Comparing the results with major agricultural goods produced in STP, the relevance of the studied chains for the country's economy becomes evident. The estimated annual trade volumes are similar to 11 t processed coffee (Salvador and Lucas, 2020) or 19.1 t fresh pepper (Fonseca et al., 2021), the 9th and 6th largest export goods by volume respectively. Also, the monetary values of the three chains are similar to exported commodities such as coconuts with US\$44,520 (7th largest export good by value) and pepper with US\$155,819 (5th; INE, 2023).

Considering the mean Santomean daily income of US\$5.46 in 2017 (World Bank, 2022), the profits generated from the sale of the three NWFPs highlight their financial appeal. During their season, baobab and izaquente accrued profits for vendors that are four times higher than average mean incomes, while safú, often only one of many products traded by vendors, lies slightly below. Throughout the year, chain participants did not exclusively focus on the particular NWFP but were involved in other economic activities. The NWFPs thereby contribute to diversifying incomes, reducing actors' economic vulnerability, and strengthening their resilience against external shocks (Kelly and Adger, 2000).

Gender is, however, a factor. While the baobab chain was occupied by men, the female participation in the other two chains was much stronger. The baobab vendors exclusively sold the very fruit in the respective season while most women in the other chains also sold other goods at the market. Even though baobab was entirely unprocessed and generated the lowest unit prices, it was still the most profitable product due to the high sales volume. This is in line with Ingram et al. (2014) that underline the gendered income dynamics in NWFP value chains in the Congo Basin, with men benefiting from better resource access, higher cost efficiencies through economies of scale and increased professionalism, leading to lower costs and higher prices in general.

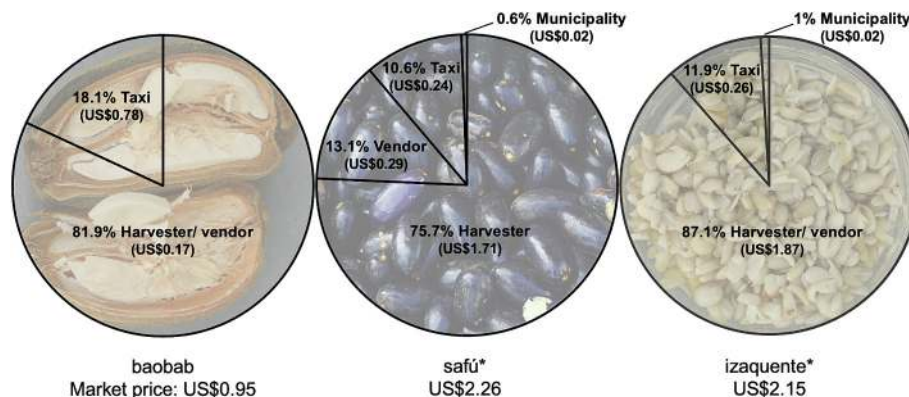


Fig. 3. Distribution of profits per kg of NWFPs sold at marketplaces.

*values in Mercado de Bobo Forro.

Most commercialized products also have nutritional values. Baobab pulp contains antioxidants and vitamin C (Chadare et al., 2009), safú provides monosaturated fats (Makouate and Lekagne, 2022) and the protein content of izaquente exceeds that of soybeans (Orwa et al., 2009c). The food value of these NWFPs, also considering the low barriers to resource access, is therefore of particular importance against the backdrop of increasing food prices and inadequate diets, identified as key development challenges in STP (WFP, 2023). The three NWFPs are not only sold at markets but are also auto-consumed by chain participants themselves. Besides, safú has medicinal uses, too. Keeping these aspects in mind, the selected NWFPs assume important safety net functions (Shackleton and Shackleton, 2004) for chain actors and beyond.

Being processed in rural areas in practices involving high levels of knowledge and skill, izaquente has an elevated social value. The rural exodus that followed the collapse of the plantation system has shrunk the rural population in STP from 69.08 % in 1975 to 24.25 % in 2022 with detrimental consequences for the country's agricultural productivity (Seibert, 2016; World Bank, 2023c) and use of indigenous knowledge. Thus, maintaining or creating further value addition could be a way to facilitate rural development, retain knowledge and counterbalance the drift towards urban areas (Coltrain et al., 2000).

The implications of this economic and social significance are critical to the effectiveness of restoration efforts. Conversely, successful FLR is likely to affect resource provision, as an increase in NWFP species stimulates supply and thus creates a need for chain and FLR stakeholders to consider power dynamics and governance in the light of sustainable, inclusive, equitable and fair development (Santos et al., 2023; Springer-Heinze, 2018; Zhu and Lo, 2021). The success of FLR in turn depends on the different values that stakeholders hold for the product, and thus the forested landscapes from which these products originate. Recognizing and aligning these values is therefore important which can be achieved by facilitating information sharing among stakeholders; a recognized way to improve sustainability and address power differences (Gereffi et al., 2005; Ingram, 2014).

5.2. Implications of plural and weak governance regimes

The environmental impact of resource extraction is difficult to assess without sufficient data on resource availability. Considering the lack thereof in STP and experiences in West and Central Africa (Ingram, 2014; Sunderland et al., 2004; Sunderlin et al., 2005), commercial utilization of the three species should be guided by precautionary principles. This is particularly so for *A. digitata* and *T. africana* as their products are harvested predominantly from wild specimens. While stakeholders of the safú and izaquente value chains did not indicate signs of unsustainability in the chains' resource node, the failure of establishing a community forest due to overexploitation is a potent indicator that baobab harvests may temporarily or locally be unsustainable.

Plural statutory and customary governance arrangements govern access to STP forest resources on paper. However, the evidence shows that both are either insufficient or non-existent. In comparison to NWFP governance frameworks in other countries of the region (Ingram et al., 2015; Stiem and Krause, 2016), the absence of traditional leadership and an associated rule system that could steer resource utilization is a characteristic of STP's history. Customary governance has been reduced to open access with the belief that anyone has the right to access the resources. This creates a tragedy of the perceived forest "commons".

Drawing on experiences in Central Africa (Ingram et al., 2011; Ingram, 2017), the weakness of statutory governance suggests long-term unsustainability of NWFP value chains unless arrangements are changed. Ambiguities in statutory provisions curtail the effectiveness of legislation and policies to govern both NWFP trade and restoration, particularly on state land. The unclarity of tolerated economic activities in the core and buffer zone of Obô National Park caused by the imprecise legislation, and consequent deficiencies in law enforcement and

monitoring, result in a low level of statutory governance of NWFP harvesting, even inside conservation zones. Fruits can effectively be harvested by anybody with quantitative limitations set by their availability. Illegal logging has an unquantified impact on the availability of the NWFPs and is an indicator of unsustainability (Ingram et al., 2015), showing the low efficacy of the regulatory framework and need for law enforcement and monitoring.

Without customarily nor statutorily granted use or ownership rights, users are not encouraged to manage resources sustainably (Ostrom, 1990; van Rijsoort, 2000). On private land and allocated agricultural areas, the extraction of NWFPs is moderated by exclusive use rights of deedholders. Nevertheless, the usufruct system is paired with concessionaires' liability to ensure productivity. Thereby, even though governance originating from this legislation prevents open resource extraction, it also creates an incentive to overutilize natural resources. Night harvesting circumvents the exclusive extraction of the grantee and can be seen as an attempt to exercise rights of access derived from customary norms.

5.3. Utility of the value chain-landscape nexus conceptualization

The results suggest valuable lessons for restoration and the development of NWFP value chains (Fig. 4).

Firstly, the value chain approach helps identify key stakeholders with vested interests in collaborating on sustaining resource availability and practices which can inform FLR. This could include a coordinated involvement of these stakeholders in planning, designing, or implementation of FLR measures (Höhl et al., 2020). The localization of harvesting areas can guide the selection of priority restoration areas considering the resource pressure there and provides information on the geographic and temporal availability of the NWFPs. The trade in products is seasonal and so are the economic benefits for the chain participants. When selecting priority NWFP species for restoration, practically in the management of the nurseries or strategically in government policies, this seasonality could be factored in to ensure a coordinated build-up of restored forest utility, complementing the seasonality of other forest and agricultural products throughout the year at household and societal level (Vinceti et al., 2022). Also, the analysis shows the preferences of chain actors regarding product characteristics, such as the size and color of baobab, which can inform the selection of phenotypes in nurseries.

Secondly, the analyses generated supply- and demand-related information on the NWFPs that can guide more effective FLR and the distribution of its benefits, as well as spur societal discussions about equity and fairness. Even without resource inventory data, there are indications that baobab exploitation is higher than the current ecological system can sustainably supply. Although with a time lag, FLR could play a pivotal role by addressing the current and predicted scarcity of resources. However, some challenges perceived by actors indicate that FLR, effectively governed in STP by commitments made under UNCCD and their implementation by TRI, is not always the most suitable instrument to generate socio-economic benefits. Not only have farmers rejected planting *T. africana* due to perceived wild abundance, but vendors also note low demand. Here, challenges such as the perishability of safú and the high workload of izaquente processing suggest that alternative interventions in value chain upgrading, e.g., product innovations, new technologies or marketing, may be socio-economically more beneficial, but would require significant support and clearer governance arrangements (Riisgaard et al., 2010).

Thirdly, the approach allows us to determine the overall cost-effectiveness of restoration ventures. While acknowledging the general potential of NWFPs, in the absence of sufficient data, the PNRFP calculates the monetary benefits of FLR merely based on the commercial timber value (DFB, 2022). This study helps to fill in knowledge gaps by expanding the dimensions of FLR's profitability to include NWFPs. According to the PNRFP, planting and maintaining an *A. digitata* costs US

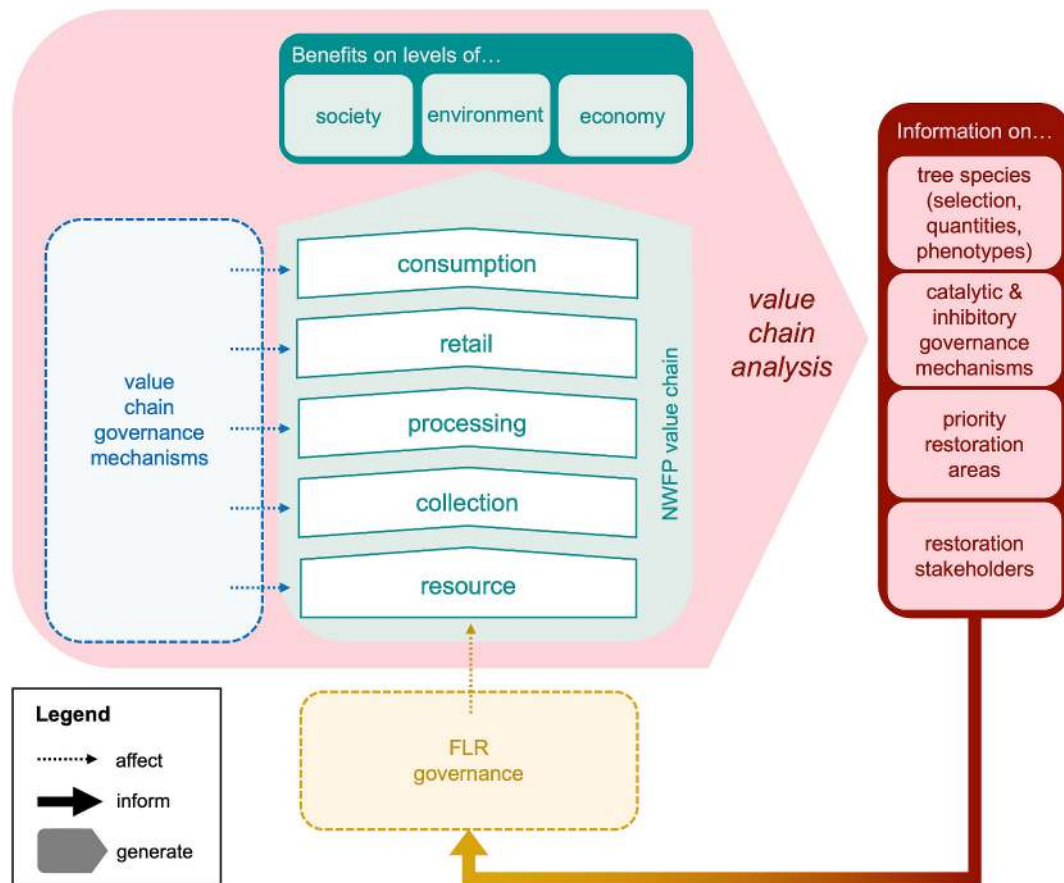


Fig. 4. Operationalization of how VCA can be used for FLR.

\$183.59 over a 20-year period whereas the costs for *D. edulis* and *T. africana* are expected to be slightly lower at US\$168.26. Our findings suggest that not only are the FLR implementation costs recoverable through NWFP harvesting but also that NWFPs utilization is economically competitive with timber production: Santomean premium grade timber is estimated to generate a once-off revenue of US\$730 for an average regional tropical tree with a timber volume of 2.05 m³ after a 20-year felling cycle (Akindele and LeMay, 2006; DFB, 2022). Not considering market demand and thereby possibly overestimating the NWFP's socio-economic potential (Peres, 2010), the revenue from timber for individual trees may be surpassed by the commercialization of raw safu in three and izaquente in two years once the trees reached maturity. This shows the potential of the chains for production-driven forest landscape restoration that could help overcome the public funding impasse (Ha et al., 2022). However, these aspects also have implications for how such competitive value chains are governed, and how benefits are distributed among stakeholders, suggesting a need for political choices if FLR is to result in improved livelihoods and restored land use systems.

Lastly, the nexus approach addresses gaps in current principles concerning landscape restoration and value chain development. Principles on ecosystem restoration (ER; FAO et al., 2021; ITTO, 2020) and landscape approaches (LA; Sayer et al., 2013) show several commonalities (Fig. 5). These include focusing on multiple scales and stakeholders, capacity development and monitoring, clear impact logic and goals. However, only ER refer to aspects of power regarding inclusion, fairness, and equity in governance. Principles steering sustainable value chains (SVCD) in development contexts have a longer history, and similarly emphasize context, stakeholder engagement, strengthening capacities and institutions, and interventions that balance multiple objectives (FAO, 2014; Gebremedhin, 2012; Springer-Heinze, 2018).

Nevertheless, advice on creating conditions necessary to advance conflicting development objectives, sustainability and co-learning is lacking (Donovan et al., 2015). In contrast to LA and ER, SVCD draw explicitly on concepts of governance and upgrading. However, they emphasize political, legal and market contexts, and assume clear governance arrangements that can provide benefits to multiple actors. Therefore, while there are many commonalities between the principles, none of the three frameworks considers plural institutional mechanisms governing products, chains, land, forests, and their restoration.

Given the context of multiple stakeholders, functions, scales and capacities of resilience and adaptivity regarding NWFP and restoration, the value chain-landscape governance nexus provides a framework in which the governance of both value chains and forest restoration is prominent. This nexus is critical as scholars have highlighted that governance is a key factor for the successful implementation of landscape approaches, such as FLR (Mansourian, 2017; Sayer et al., 2013), and value chain enhancement in development contexts (Ingram, 2014; Nguyen et al., 2020).

5.4. Study limitations

Trade of the three NWFPs in STP is seasonal. Although fruiting periods corresponded with data collection, data on traded amounts over longer periods would lead to more robust data that considers geographical, seasonal, and annual variations in production and trade.

Moreover, the focus on goods commercialized in formal marketplaces means that informal trade was virtually disregarded. The study design also did not directly consider the consumer node of the chains. Information on consumption is, however, instrumental to provide a more holistic quantification of a product's total use and the corresponding pressure on the species' abundance. To quantify both informal



Fig. 5. Commonalities between principles guiding landscape approaches, landscape restoration and sustainable value chain development.

Additional Information: ER = Ecosystem Restoration principles (FAO et al., 2021; ITTO, 2020), LA = Landscape approach principles (Sayer et al., 2013), SVCD = Sustainable Value Chain development principles (FAO, 2014).

trade and consumption, a household level survey could be used to collect such data.

Finally, limitations regarding the quantitative validity of the research exist. Although the survey covered a large share of vendors based on spot counts during participant observation, statistical analysis is impaired by the small numbers and limited duration of the study. Quantitative data was affected by an absence of documentation of trade figures by respondents, being based on memory recall and rough estimates. Particularly also for qualitative information, this was mitigated by applying different data collection methods that could triangulate the findings and thereby enhance the validity of our study.

6. Conclusions

In STP, various NWFPs are commercialized and anchored in governmental strategies where their promotion is envisioned to yield positive socio-economic and environmental outcomes in the country's FLR efforts. Three species that are highlighted are *A. digitata*, *D. edulis* and *T. africana*. However, despite trade and utilization of their products being commonplace within the Santomean society, there has been a lack of understanding of the socio-economic relevance of these chains and

how they are affected by existing governance arrangements. This study took a value chain approach to investigate these aspects.

Even though the studied chains are embedded in a small island state setting, affecting their scope and trade patterns both geographically and in terms of volume, they compare with value chains of these products in countries on the African mainland regarding their socio-economic relevance and governance. We showed that the three chains are of high economic and social significance on an individual and societal level. However, the overall weakness of the different regimes governing the landscapes and their value chains puts the sustainability of NWFP trade at risk. This has implications for successful FLR. Most importantly, access to the resources would need to be moderated by the government or other actors with authority. Besides, also involving value chain stakeholders in restoration activities could be benefit long-term FLR objectives.

Bringing together the conceptualizations of a value chain, value chain governance and landscape governance is a novel approach that can provide a more comprehensive understanding of resource dynamics and trade, linking forest restoration to aspects of supply and demand. In this value chain-landscape governance nexus, activities and actors involved in the harvest, trade, and restoration of NWFPs converge and

their interrelations become visible.

This study only looked into the relevance of three of the numerous NWFPs commercialized in STP. Despite the reasoned selection process, a weighted importance of the three species in relation to others cannot be postulated. Therefore, future research on other NWFPs in the country would be beneficial. This could be complemented with an exploration of the ecological role of NWFP species within different land use settings and with research on the significance of these chains on a household level. Of interest would also be studying how the country's colonial legacy is linked to the future of NWFP chains within the FLR framework. Finally, regarding the conceptualization, the value chain-landscape nexus could be tested for its robustness, for instance in different contexts or with a focus on inclusion, fairness, and equity in the governance.

CRediT authorship contribution statement

Lorenz R. Schimetta: Writing – original draft, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Verina J. Ingram:** Writing – review & editing, Supervision, Methodology, Conceptualization.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

Lorenz R. Schimetta declares that administrative support and travel were provided by Food and Agriculture Organization of the United Nations (FAO) and by the São Toméan Directorate of Forests and Biodiversity for the fieldwork.

Data availability

Data will be made available on request.

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Appendix A. Supplementary data

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