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Connecting rural non-timber forest product collectors to global markets: The case of baobab (*Adansonia digitata* L.)

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ABSTRACT

Although the importance of non-timber forest products (NTFPs) is increasingly recognised across the globe, their potential is not yet fully realised. Their often valuable nutritional composition and discovery of new possible applications offer further opportunities for innovation and rural development. Yet only few NTFPs manage the jump from traditional, informal use to global markets. Therefore, this paper assesses how baobab (*Adansonia digitata* L) fruit products overcame the challenges faced by most NTFPs in gaining access to such markets, discussing factors contributing to its emergence and how sustainability aspects were addressed. Complex interactions of a variety of actors and institutions in the global South and the global North, encompassing both the production as well as the consumption side, were necessary for these developments. Triggered by the rising demand for natural, healthy foods and growing knowledge and appreciation for indigenous products, increasing numbers of entrepreneurs and development organisations entered the scene. Poor climates for innovation and enterprise development in the producer countries were overcome by developing the sector bottom-up using external support inducing a variety of innovations including supply chain modifications in order to comply with the high quality standards demanded. With baobab previously unknown to Western consumers new markets were formed due to the combined efforts by a variety of both private and public stakeholders and demand for baobab fruit powder rose to several hundred tons per year after the acceptance as novel food in European and US markets. Numerous products are now available predominantly in niche, early adopter markets focusing on healthy or organic foods. However, further support of the sector is necessary to ensure sustainable commercialisation of baobab resources. With the developmental impact being higher the more ethically, sustainably sourced baobab is sold, activities focusing on increasing demand and raising awareness on the consumer side may well have a higher impact than direct efforts aimed towards the production systems.

1. Introduction

The diverse and important roles non-timber forest products (NTFPs) play across the globe are increasingly being acknowledged. Particularly in the global South NTFPs often play a vital role for rural livelihoods. Almost 80% of rural households across Asia, Africa, and Latin America collect wild foods (Hickey et al., 2016) and forest environmental resources in general can account for significant shares of rural household income with estimates ranging from 21 to 27% (Angelsen et al., 2014; Babulo et al., 2009; Vedeld et al., 2007). Yet, even in Europe about a quarter of households collect NTFPs, predominantly for subsistence use and recreational purposes with an estimated economic value of 23.3 billion € per year (Lovrić et al., 2020). Wild foods from forests often are important providers of micronutrients and can improve household dietary diversity (Garekae and Shackleton, 2020; Hall et al., 2019; Ickowitz et al., 2014; Powell et al., 2011; Rasolofoson et al., 2018; Rowland et al., 2017), whereas commercialisation of NTFPs can be an important source of cash income, particularly for poor, cash-constraint households (Fandohan et al., 2010; Le and Nguyen, 2020; Mahapatra et al., 2005; Rijal et al., 2011; Worku et al., 2014).

However, the potential NTFPs offer is by far not exploited yet. Their often special nutritional composition alongside progressing technological development and discovery of new uses offers further opportunities for new product development and innovation (Aworh, 2015; Chamberlain et al., 2020; Leakey, 1999; Nitcheu Ngemakwe et al., 2017; van Wyk, 2011). For example, extracts derived from chestnut have been

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shown to be adequate substitutes for chemical additives used in baking (Caleja et al., 2020), and innovative product formulations with NTFPs labelled as 'superfoods' are continuously being developed, following the discovery of their phytochemical composition potentially benefitting health (Chang et al., 2019; Kirthika and Janci Rani, 2020; Matta et al., 2020; Nitcheu Ngemakwe et al., 2017). Our forest biodiversity offers yet a vast reservoir of potential further applications (Chamberlain et al., 2020), which is likely to be exploited further due to the constant search of the food, cosmetics, or pharmaceutical industries for novel ingredients with technological or health-boosting properties, coupled with the increasing demand for more natural and ethically sourced products as well as functional foods (Arenas-Jal et al., 2020; Bigliardi and Galati, 2013; Grunert, 2017; IFAD, 2021). NTFPs have high potential to supply this demand with appreciation for wild, indigenous foods rising across the globe (Aworh, 2015; Darr et al., 2020; Wiersum, 2017). Since NTFPs typically are located in remote areas with little employment (Cunningham, 2011; Ham et al., 2008; IFAD, 2021), such opportunities may also offer chances for value addition and enterprise development in rural areas, which in turn can lead to additional employment and generation of income (Aworh, 2015; Saka et al., 2008; Tewari, 1998; Tieguhong et al., 2012).

Products derived from the large, deciduous baobab tree (*A. digitata* L.), a species widely distributed within semi-arid to arid savannahs and savannah woodlands of mainland sub-Saharan Africa (Wickens and Lowe, 2008), are a typical example in this regard. Whilst recognising vast regional differences in extent and type of usage, overall almost all parts of the tree including the leaves and fruits, the bark or the roots have been reported to be of traditional value for local communities e.g. for the provision of food, medicine, fodder, handicrafts, or significance in cultural ceremonies (Gebauer et al., 2016; Kamatou et al., 2011). Besides their traditional use, however, products derived from its fruit also underwent a rapid development in recent decades: in particular oil derived from the seeds for the use in cosmetics and powder derived from the fruit pulp for nutritional purposes are nowadays important ingredients for oversea markets as well (Kamatou et al., 2011). For example, more than 300 products containing baobab have been identified on the European market (Gebauer et al., 2014). In the Southern African Development Community (SADC) region trade of baobab resources for international markets has been estimated at 187.5 t powder/year as well as 5.22 t oil/year (Kruger and El Mohamadi, 2020). Yet also on the African continent baobab products are transitioning from solely traditional use to higher-value market segments (Darr et al., 2020), taking advantage of the special nutritional composition of the baobab fruit with its high values of Vitamin C, dietary fibre, or phytochemicals and associated health benefits (Braca et al., 2018; Chadare et al., 2009; Coe et al., 2013). These features offer opportunities for functional food product development (Gabaza et al., 2018; Mpofu et al., 2014) and reduction of the risk of micronutrient deficiencies (Mounjouenpou et al., 2018; van der Merwe et al., 2019). Since the fruit pulp is naturally dry when the fruit is ripe it can easily be added and enrich foods such as cereals, snack-bars, and cookies, hereby increasing nutrient intake. Responsible baobab fruit value addition and commercialization has also been shown to be an important additional income source for smallholders (Venter and Witkowski, 2013b).

Overall, however, despite the opportunities professional NTFP commercialisation is often still in its infancy in the global South (Ham et al., 2008; Jordaan et al., 2008; Saka et al., 2008). Indigenous fruits often only undergo minor, if any, value addition (Nitcheu Ngemakwe et al., 2017) and only few NTFPs have managed to enter high-end markets or are found in a wide range of products (Chamberlain et al., 2020; Cunningham, 2011). Notwithstanding that such opportunities may only prevail for selected NTFPs, the value of such markets should not be underestimated and reaching these may well be a worthwhile strategy to pursue to improve smallholder producers' livelihoods (Chamberlain et al., 2020; Cunningham, 2011). To truly advance benefits derived from forests and foster inclusive global NTFP value chains the often poor innovation environment for NTFP enterprises (Živojinović et al., 2017) needs to be overcome, recognising that besides product innovations also organisational, (Liu and Xu, 2019; Macqueen et al., 2020; Pratono, 2019), market (Sardeshpande and Shackleton, 2019), or technological (Ao et al., 2021) innovations are necessary. Therefore, the main aim of this manuscript is to analyse how a high-end NTFP industry and associated markets for these products can emerge using baobab as a case study. To elucidate which factors foster such a development a variety of questions are addressed, such as: what were the necessary framework conditions; which role did different actors and institutions play; what were the main supporting and hindering mechanisms; how were capabilities formed to develop baobab innovations and create demand for these products in international, high-end markets; or have any particular mechanisms been put in place to ensure ecological and social sustainability. Such initial processes and steps during the emergence of novel industries have, so far, received relatively little attention (Gustafsson et al., 2016), particularly concerning low-tech industries in the global South; yet a better understanding of the underlying steps and processes can help derive important lessons learnt for other commercially important NTFPs.

In the following we will first outline the main theoretical approaches used in the paper, focussing on innovation systems as well as the emergence of industries and markets. Second, after a brief description of the methods applied, the results will delineate the main stages of the development of the high-end baobab industry, highlight main innovations and associated market formation activities, as well as the main mechanisms and enabling and hindering factors involved in these processes. Findings are then synthesised highlighting how baobab overcame typical challenges concerning NTFP market development, and illustrating the complexity of the process and multitude of actors and institutions involved or the importance of entrepreneurship or quality standards. Sustainability implications are discussed and comparisons to other NTFPs available on high-end markets drawn. The paper concludes with recommendations for a further sustainable development of the baobab sector.

2. Conceptual framework

To better understand processes and changes in ever evolving industries and markets, different theoretical approaches have emerged. One of the key approaches used is the technological innovation systems (TIS) framework. The overall basis lies in innovation systems literature, which can help comprehend innovation, the development, diffusion, and adoption of new technologies, services, and practices (Aubert, 2005), which is considered key for economic development (Nybakk et al., 2009; Rametsteiner and Weiss, 2006). Innovation systems encompass the complex set of relationships amongst the different actors in the system, as well as influencing factors such as laws, policies, standards or social norms (Edquist, 1997). The approach was shaped originally by the works of e.g. Lundvall (1992), Nelson (1993), as well as Freeman (1995). Initially, the focus was on national systems of innovations, yet related concepts setting different system boundaries soon emerged, including regional, sectoral, or aforementioned TIS. With a basis also in the works of Carlsson and Stankiewicz (1991), TIS can be understood as the set of actors and institutions interacting in a specific technological field and contributing to the development and adoption of related technologies and products (Markard and Truffer, 2008). Offering the advantage that it can cross geographic as well as sectoral boundaries, TIS is also one of the main approaches used to study innovation in forestry (Weiss et al., 2020). Several conceptual developments have since advanced the concept, most importantly TIS functions to better be able to understand the performance of the system. Although these functions can somewhat differ in the scholarly literature, most commonly aspects such as entrepreneurial activity, knowledge development and diffusion, resource mobilisation, legitimisation, or market formation are included (Bergek, 2019; Bergek et al., 2008; Hekkert et al.,

2007; Hekkert and Negro, 2009). These functions have for example been applied to study innovations and system dynamics in biodigestion (Tigabu et al., 2015), biorefineries (Giurca and Späth, 2017), or multi-storey wood-frame constructions (Lazarevic et al., 2020).

Overall, the TIS approach is now widely used to study the creation and growth of new industries (Markard et al., 2015). To better be able to highlight the dynamics of the system, our conceptual framework yet also draws upon insights from industry life-cycle theory (Fig. 1), which aims at identifying and explaining patterns occurring during the aging of industries (Peltoniemi, 2011). Typically early, growth, mature, and declining stages are differentiated across the overall industry life cycle, accompanied by associated modifications in industry structure and innovative behaviour. For example, over the life-cycle of an industry changes in terms of firm numbers (Jovanovic and MacDonald, 1994), innovative activities (Audretsch and Feldman, 1996), or enterprise characteristics (Agarwal and Bayus, 2004; Covin and Slevin, 1990) have been documented. As an industry progresses, firm numbers typically make up an inverted U-curve, whereas in terms of innovations product innovations are followed by process innovations (Peltoniemi, 2011).

Due to the role new industries can play in economic development the earliest stages of an industry life cycle deserve particular attention. During the emergence process of a novel industry commonly three phases are distinguished (Gustafsson et al., 2016). In the initial phase the existing status quo is challenged, triggers for which can stem from scientific and technological advancements (Phaal et al., 2011), or cultural and regulatory changes in society (Lechner and Pervaiz, 2021; Lounsbury et al., 2003). High levels of uncertainties prevail as resources for product and process development as well as commercialisation activities are scarce, markets do not exist yet, or consumer needs are unclear (Gustafsson et al., 2016). Nevertheless, the entrepreneurial opportunities this phase offers triggers firms to enter (Mezias and Kuperman, 2001; Sine and Lee, 2009). The co-evolutionary or emergent phase (Forbes and Kirsch, 2011) is characterised by increasing number of innovations in the field across the value chain (Zhang and Gallagher, 2016), rising levels of firm entry (Klepper and Graddy, 1990) and collaborative actions by industry stakeholders to build legitimacy (Burr, 2006; Mezias and Kuperman, 2001). Different technical or organisational approaches emerging in this period due to increasing competition may later converge, fostered by networking of players active in the industry (Gustafsson et al., 2016; Rosenkopf and Tushman, 1998). Enterprises thus shape the emerging industries they are involved in via processes arising both from competition as well as cooperation (Santos and Eisenhardt, 2009). A transition to the early growth phase can then occur if sufficient organisational support is present (Wade, 1995). This phase is characterised by industry sales finally taking off and yet increasing firm numbers (Agarwal and Bayus, 2004), changing the industry landscape permanently (Gustafsson et al., 2016). Often a common understanding on prevailing standards amongst industry players, e.g. in terms of a 'dominant design' (Abernathy and Utterback, 1978; Murmann and Frenken, 2006), is achieved, which in turn may foster further developments in the industry due to a reduction in uncertainties (Gustafsson et al., 2016).

A vital process alongside industry emergence is the emergence of the corresponding markets, which are needed to ensure the viability for the industry in question. The complexity of this process is increasingly recognised (Sprong et al., 2021), with both actions of market actors as well as the surrounding institutional environment playing important roles (Baker et al., 2019; Nenonen et al., 2019). While the demonstration of the viability of the innovation in question is crucial (Phaal et al., 2011; Takano and Kanama, 2019), this is seldom enough to create demand and a market for it. It has to be understood that demand is created in a particular socioeconomic setting, influenced by a variety of values, norms, and beliefs (Baker et al., 2019; Lounsbury et al., 2003; Sine and Lee, 2009). For foods products a high level of consumer trust is a particularly important factor (Nuttavuthisit and Thøgersen, 2017). Thus, to create the needed legitimacy (Schultz et al., 2014) in such

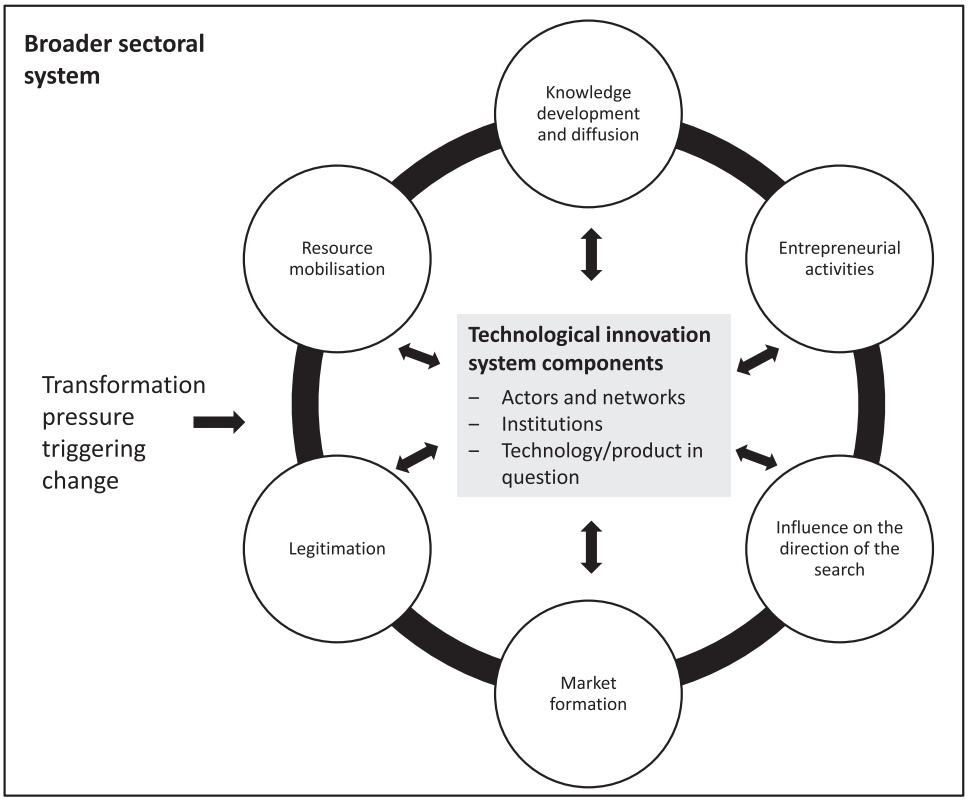

Fig. 1. Overall conceptual framework, adapted from Haley (2018), and Suurs and Hekkert (2012). Over the industry life cycle structural components as well as the role of different TIS functions can change.

complex settings, an interplay between different market actors is needed (Burr, 2006). The activities of entrepreneurs in the market are vital components in this regard, whereas both competition and collaboration processes are key instruments purposefully shaping arising markets (Beninger and Francis, 2021; Santos and Eisenhardt, 2009), yet market creation can also be primarily driven by consumers (Martin and Schouten, 2013). The regulatory environment is yet another important player in the development of emerging markets and industries (Hung and Chu, 2006). The successful interplay between all these elements can then finally lead to a critical mass, and subsequently sales take-off (Agarwal and Bayus, 2002).

3. Methods

Since qualitative methods have been put forward to play a particular important role in researching emerging industries (Forbes and Kirsch, 2011), qualitative empirical data was collected to better holistically understand the framework conditions of the emerging baobab industry and corresponding markets. Interviewees ranged from enterprises active in processing, exporting, and distributing baobab resources ($n = 8$), importing brands ($n = 3$), as well as actors who supported the overall establishment of the international baobab industry and markets ($n = 2$), whereas some interviewees were active in more than one of these subgroups. Semi-structured qualitative interviews were conducted in September 2017 and repeated in January 2021 in order to be able to deduce ongoing developments in industry formation. In total 18 interviews were conducted, transcribed, and analysed, whereas both the categories of questions asked as well as the subsequent analysis were guided by the underlying literature concerning the research focus and theoretical framework. Thus, interview questions focused on potential triggers for the development of the high-end baobab sector, main events in time during sector establishment including key actors and institutions involved in the process, main innovations developed, how markets were stimulated and sustainability aspects taken care of, as well as which supporting and hindering factors both in financial and non-financial terms were relevant for these processes according to the perception of the interviewees. Data collection functioned in an iterative manner, ending when no new information on a respective topic became apparent. The interview data was coupled with additional written information provided by the interviewees, sector reports and online accessible secondary sources concerning the developing baobab sector to ensure data triangulation. All data obtained were then coded using MAXQDA 2020 (VERBI Software, 2019). A deductive coding process was applied based on the research framework, with the initial set of codes consisting of a) triggers for high-end baobab product development; b) core events in time; c) involved actors and networks; d) involved institutions; e) innovations; f) market development; g) contributing and hindering factors having an impact on the sector; and h) sustainability implications. More detailed codes were added while assessing the data in depth, for example by further distinguishing innovation types such as product, process, marketing, or organisational innovations. The identified contributing and hindering factors were in a second step deductively coded to the TIS functions 'knowledge development and diffusion', 'entrepreneurial activities', 'influence on the direction of the search', 'market formation', 'legitimation', and 'resource mobilisation', with these functions currently dominating the field (Bergek, 2019). To be able to further characterise the functionality of the system, subsequently frequencies of these themes were identified. Finally, to further triangulate the data a scientific literature search was conducted using Web of Science to identify previously published literature on baobab concerning the different topics covered in this manuscript. In doing so, a special focus was put on potential sustainability implications concerning baobab resources, in order to counteract the common problem of the TIS approach not including sustainability aspects (Bélis-Bergouignan and Levy, 2010; Weiss et al., 2020).

4. The emergence of a novel high-end NTFP industry

4.1. The early beginnings of the baobab industry

The time was right for a more professional approach towards baobab commercialisation in the late 1990s and early 2000s, inspired by a growing natural products industry and triggered by a mix of entrepreneurial drive as well as efforts from development organisations. At this stage there was no market for baobab products in the global North with baobab being unknown to Western consumers. Solely traditional, informal use and trade of baobab resources prevailed in producing countries, supported by simple processing technologies such as pounders and mortars (Bennett, 2006). Investigations into NTFPs, their traditional uses and knowledge associated with these products, as well as potential further applications then fostered the identification of baobab as a priority species for pro-poor commercialisation and facilitated further innovation and development of products and technologies. Interestingly, activities to more professionally commercialise baobab started in parallel of each other almost simultaneously both in Senegal and Southern Africa, firstly Malawi, on top of its traditional applications. The Senegalese development was dominated by the passion of an individual entrepreneur, setting up the Baobab Fruit Company located both in Senegal and Italy, serving as the initially targeted European market. From the start in 2001 they were the first to import baobab fruit pulp for use as dietary supplements into the EU (Gruenwald and Galizia, 2005), and specific baobab fruit processing machines were developed in collaboration with universities (Sidibe and Williams, 2002). Until 2008 they were the only baobab producers exporting, albeit in small quantities, to Europe, and until today Senegal remains a major player in terms of exporting baobab resources.

In Southern Africa, activities to sustainably commercialise baobab were stimulated by the Southern African Natural Products Trade Association PhytoTrade Africa, founded in 2001. Aiming to improve rural livelihoods by developing a sustainable natural products sector (ICTSD, 2007), PhytoTrade added baobab to their list of high-potential species (Bennett, 2006), inspired by ongoing donor-funded activities in Malawi establishing baobab juice for the local market, which in turn had been initiated by observed traditional use of baobab. This also shifted PhytoTrade's initial focus from baobab oil to fruit powder due to higher perceived development impact and efficiency, with less by-products being generated. Early estimates suggested that baobab had the potential of becoming a billion dollar industry for Africa, employing over 2.5 million households (Bennett, 2006). PhytoTrade enabled, via the support of its donors, various activities building the baobab sector, including research into technology establishment, assessment of the resource base and potential products, or market development activities (ICTSD, 2007). The first enterprise targeting the export market linked to PhytoTrade, TreeCrops, was founded 2006 in Malawi, and, as all PhytoTrade members, integrated ethical bio-trade principles and a focus on aspects such as traceability, sustainability and hygiene risk management practices (Bennett, 2006). Yet before broader export of baobab fruit powder could commence, regulatory obstacles such as the European novel foods regulation had to be addressed. To demonstrate baobab's safety for human consumption, PhytoTrade facilitated all needed tests, and in 2008 the EU novel food application was finally approved (EC, 2008), followed shortly by the FDA approval for the US market (FDA, 2009).

4.2. Evolution to a globally operating industry

The international high-end baobab sector was off to a difficult start with the opening of European and US markets coinciding with the global financial crisis, and food manufacturers cautious about new product development (NPD) activities (Zouaghi and Sánchez, 2016). Yet from approx. 2010 onwards, with overall demand slowly starting to rise, more products containing baobab started to appear on Western shelfs,

although often only in small quantities (Gebauer et al., 2014). International demand for baobab fruit powder rose in a volatile fashion, with export of baobab fruit powder to main Western markets currently being estimated at several hundred tons per year, from basically nothing approx. 20 years ago.

Correspondingly, further actors in both producer and consumer countries entered the scene seeing commercial opportunities, including additional baobab producers as well as distributors, brands, food manufacturers, or even specialised machinery manufacturers. Concerning baobab producers, initial adopters were primarily other PhytoTrade members across Southern Africa, aided by the knowledge generated and shared across the network. To be accepted as member, applicants had to demonstrate and upon acceptance sign legal charters, committing to principles of Fair Trade and environmental sustainability (Welford and Le Breton, 2008). The Baofood Fruit Company inspired further baobab producers to set up enterprises in Western Africa and, nowadays, with information concerning the production of high-quality baobab being more readily available, further producers across Africa have entered the formal market more independently. However, despite the fact that baobab is found in approx. 30 countries across Africa, the number of serious baobab exporting enterprises is yet below a dozen, with the most important exporting countries including Zimbabwe, South Africa, Mozambique, Senegal or Ghana. These countries differ strongly in terms of baobab density or intensity of traditional use of baobab resources, suggesting that these factors are not of primary importance for accessing the export market. The fact that many of the pioneering enterprises are still involved in the sector highlights the difficulties and risks individual entrepreneurs face in this novel industry, with markets not fully established or best supply chain configurations not fully understood yet, which has already led to the demise of some businesses.

Whereas initial collaboration, particularly amongst PhytoTrade members, was probably vital to get the sector off the ground in the first place, the increasing competition has become apparent. In order to not lose their competitive advantage producers over time have become more careful in sharing information about their production process, such as processing equipment, pricing, or supplier organisation, although it is acknowledged that collaboration on aspects focusing on growing overall demand and awareness for baobab is beneficial. The increasing competition amongst baobab producers has also led to a reduction in the market price for baobab fruit powder, which currently lies in the range of 8–14€/kg for certified organic powder sold B2B, from about 35 €/kg in 2004 (Gruenwald and Galizia, 2005). With more producers entering and prices dropping there is a risk for lower quality baobab accessing international markets, not following the ethical principles the pioneering producers had at heart. These considerations, together with the demise of PhytoTrade in the mid-2010s, fostered the formation of the African Baobab Alliance (ABA) in 2018. The ABA, a pan-African initiative consisting of key industry players, aims to raise quality standards for baobab, grow global demand, and promote sustainable, reliable and ethical supply chains – thus, enabling better differentiation in the baobab industry in the future.

4.2.1. Innovation in the high-end baobab processing industry

Considering innovation in the high-end baobab sector, the perhaps key aspect is the conversion of an informal, traditionally-used product to a commercially oriented formal value chain; or as one of the producers put it: "*how do you manage to get a product that is traditionally collected on the ground, opened on the ground with rocks, taken out the shell with dirty hands, put into a previously used fertilizer sack, taken back to the house, stored with whatever, and then sold on the street side. How do you take it from there to getting it into a product made by food manufacturers with the highest possible standards on the planet for food? Yeah. That's where we've come in*". Yet the entire high-end baobab processing industry cannot be characterised by a single innovation. The sector has been formed by a multitude of innovations across the value chain (Table 1), many of which on the supply side were initiated using grant financing in contrast to private sources. Overall, innovations in the sector arose more in iterative, incremental ways, with particularly the pioneers constantly being engaged in trial and error, learning from their own experiences and that of the communities and other value chain members.

Table 1
Overview of innovation types in the nascent baobab industry.

Innovation type (IT)	Frequency IT mentioned	Main examples
Product innovation	19	– Novel product formulations with baobab fruit powder as an ingredient, including e.g. sports and energy drinks, drink powders, smoothies, supplemental superfruit blends, bars, chocolates, capsules, prebiotic and symbiotic products, dairy products, etc.
Process innovation	9	– Baobab pulp processing machines, filtering/sieving systems – Storage systems
Organisational innovation	21	– Supply chain organisation in producer countries and quality control procedures – Shareholding structure to involve smallholder producers – Logistical advancements to allow bulk sales – Collaboration with (subcontracted) specialists, e.g. for NPD or positioning of products
Marketing innovation	3	– Novel B2C approaches to marketing by baobab brands to tackle low consumer awareness

In relation to baobab producers, organisational innovations have been particularly important to meet requirements for export markets, which are not only set by the legal framework, but increasingly also from food manufacturers themselves, who may apply even more stringent requirements if an ingredient is to enter their production facility. In order to ensure and demonstrate appropriate microbiological levels, pesticide and heavy metal contents, hygienic practices in processing facilities, or traceability, baobab producers had to learn to adapt their supply chain. Systems to organise thousands of baobab harvesters in rural Africa had to be established, allowing for batch tracking and quality control throughout the sourcing and production process. Much efforts, including grant funding, has also gone into baobab processing equipment development. Originally pushed by efforts from pioneer baobab producers via continuous trial and error, to a certain degree independently amongst producers, today it has reached a level where it is possible to buy appropriate machines on the market, although there is still scope for advancements, particularly considering cost-effective, small machines used directly at community level (Dikson, 2015). Overall, and although differences in the way producers buy, secure, and process fruit still exist, certain trends towards convergence in the production process can be observed in case the export market is targeted. These include, for instance, strict guidelines for fruit collection and storage, or more centralised fruit processing using advanced processing equipment. Purchase of pre-processed baobab fruit pulp from harvesters or purchase of baobab from traders is discouraged, since quality, consistency, and traceability is more difficult to ensure.

In terms of the consumer side, baobab has also come a long way with increasing amount of high-end products available, both in African as well as Western markets. The high pectin and fibre content in baobab fruit pulp makes it an interesting ingredient from a food technology perspective, since it can be used as a thickening agent (Bennett, 2006; Gruenwald and Galizia, 2005). Besides baobab fruit powder itself serving as a healthy, nutritional supplement, a variety of product concepts integrating baobab powder have been developed (Gebauer et al., 2014; Gruenwald, 2009). A fully soluble depectinised, liquid extract offers further application possibilities, particularly for the beverage industry, and extracted components such as polysaccharides may be used

in the food or pharmaceutical industry (Alba et al., 2020; Tsetegho Sokeng et al., 2019). Thus, further product innovations are likely, especially in the functional foods segment, although more research into the potential health benefits of baobab is needed.

4.2.2. Market development

The most important export markets for baobab (excluding intra-African trade) include North America and Europe, with the UK and Germany probably dominating the European side. Besides smaller amounts targeting the African diaspora, the main target consumers can be attributed to the LOHAS (*Lifestyles of Health and Sustainability*) demographic. As such, baobab is still an early adopter market, sold primarily in health or organic stores. Correspondingly, its value proposition typically focuses on baobab's outstanding nutritional properties and the majority of exported baobab is organically certified. Serving these niche markets, it is typically small, young brands incorporating baobab into their products. Whereas the market for pure baobab powder seems to slowly become saturated, further developments in NPD for more complex products are expected. Furthermore, more mainstream food manufacturers have started utilising baobab, also via the possibility of using baobab extract.

With baobab previously being an unknown ingredient for Western consumers, such markets for baobab first had to be developed and various activities conducted to raise awareness amongst both the food industry and consumers, focusing on and aided by the growing trend for natural, healthy foods (Grunert, 2017). Early market awareness until the early 2010s were dominated by PhytoTrade's activities, aiming at continuous engagement with the market to avoid baobab becoming a fad-type product. Activities included establishment of partnership with market participants, starting already at R&D level for NPD, or providing underlying information such as research results to its members for their respective marketing campaigns (ICTSD, 2007). Until the early 2010s it was predominantly PhytoTrade members promoting baobab at relevant international trade shows. With more stakeholders entering the scene, market forming activities were increasingly also undertaken by brands or distributors besides baobab producers. Low consumer awareness in the target countries was addressed via PR campaigns and promotional programs including social media, in-shop advertising, or special efforts into branding, with selected brands such as Aduna investing most of their available resources into marketing activities. Constant efforts targeting the food industry directly, e.g. via participation in trade fairs or directly showcasing novel ideas, were also conducted to enhance the opportunities of market uptake.

This early focus on export markets is not undisputed amongst industry stakeholders: "*It's an African plant, we should have started in Africa. There we don't have all these regulations, there you don't have all these trade barriers, and so on […]. So we probably would have been better off if we would have said right, we are going to sell a baobab drink, develop cereal bars in Africa and so on. And make our money there and while we make our money there, we are slowly going to invest into the breaking open of the EU market. We have done it the other way around. Basically we have wasted a lot of time and money and we would have been a lot better off if we had developed the African market*". Nevertheless, most baobab producers nowadays also target their respective local markets, recognising the rising potential: "*So, you know if Germany or UK decides not to buy our baobab, then I hope in 10 years' time we won't need them*". In many countries where baobab previously has been seldom consumed it is slowly losing its 'poor people's food' image (Meinhold and Darr, 2020) and an increasing product differentiation can be observed, including also high-quality products sold via local supermarkets (Darr et al., 2020).

4.3. Functional analysis of the development of the baobab industry

Considering the high-end baobab industry at a macro level, a variety of actors, institutions and inducing factors contributed to the fact that baobab made the jump from an informally-used product to a globally-used superfood (Fig. 2). Whereas initially resource mobilisation was the most frequently mentioned positively contributing factor, knowledge development and diffusion gained importance after legitimation was achieved and international markets could be accessed.

Nevertheless, different blockages have made this overall development more difficult than one may expect and need to be tackled in future for a further sustainable development of the sector. Table 2 highlights the identified inducing and inhibiting factors assigned to the respective TIS functions applied across the overall timeline of the sector's development. The broad variety of topics mentioned highlight that in the case of baobab it was more the complexity of actions rather than a single factor which brought the industry to a global level. For example, interviewed enterprises reported that so far conducted research on health research, which demonstrated e.g. that consumption of baobab can have a positive effect on glycemic response (Coe et al., 2013) or on the subjective perception of satiety (Garvey et al., 2017), often led to a short-term boost in sales, however constant marketing efforts targeting both consumers and the food industry were vital to avoid baobab becoming a fad-type product.

Although most identified contributing and hindering factors could easily be matched to the functions used, selected issues mentioned by the interviewed experts remained. The first set of such factors refer to the resource itself; baobab fruit due to its particular nutritional properties can create perceived additional benefits for consumers and food manufacturers, justifying its high price. Furthermore, its taste, although not as overwhelming as other tropical fruit, is pleasant and not as intense as other superfoods such as moringa, and can easily be combined with other ingredients. In selected countries baobab remains little utilised while being widely distributed, creating a marketable surplus. Its distribution amongst rural smallholders offers both opportunities and risks: whereas income generating opportunities can be established in case the supply chain is ethically organised, exploitation can easily occur in case it is not. Nevertheless, the establishment of needed quality control procedures amongst rural harvesters to reduce risks of microbiological contamination, which is a common risk amongst African produce (Akhtar et al., 2014; Hell et al., 2009), and necessary down payments in cash make it a risky business for exporting baobab producers. Success cannot be taken for granted, particularly due to highly uncertain market demands in the early stages of this developing industry.

4.4. Addressing sustainability in the industry

Considering no baobab plantations exist to date and the species predominantly occurs in dry, rural Africa alongside often marginalised communities, special considerations need to be put on sustainability aspects. Nevertheless, it first has to be acknowledged that vast differences prevail across the continent. Particularly in Western Africa, yet also in countries such as Sudan or Malawi, high levels of local consumption and potential overexploitation have been observed (Buchmann et al., 2010; Sanchez, 2011); whereas in countries such as Kenya or South Africa the species can still be regarded as underutilised and increased commercialisation suggested to be an important pathway to increase rural income, especially for women (Fischer et al., 2020; Jäckering et al., 2019; Venter and Witkowski, 2013b). Overall, although fruit harvesting reduces seed availability and subsequently may negatively affect baobab recruitment, it has been demonstrated that the species shows relatively high tolerance to fruit harvesting, also in production landscapes (Venter and Witkowski, 2013a). Leaves harvesting has a higher impact on the species' biology, yet, overall the species is quite resistant due to its longevity and low mortality rates (Schumann et al., 2010). Possibly more important threats to the species include land clearance for agriculture, climate change impacts, high livestock numbers, or predation of immature fruit by baboons (Venter and Witkowski, 2013a). With regard to commercialising baobab fruit (the only part of the tree currently targeted for Western markets), it has been

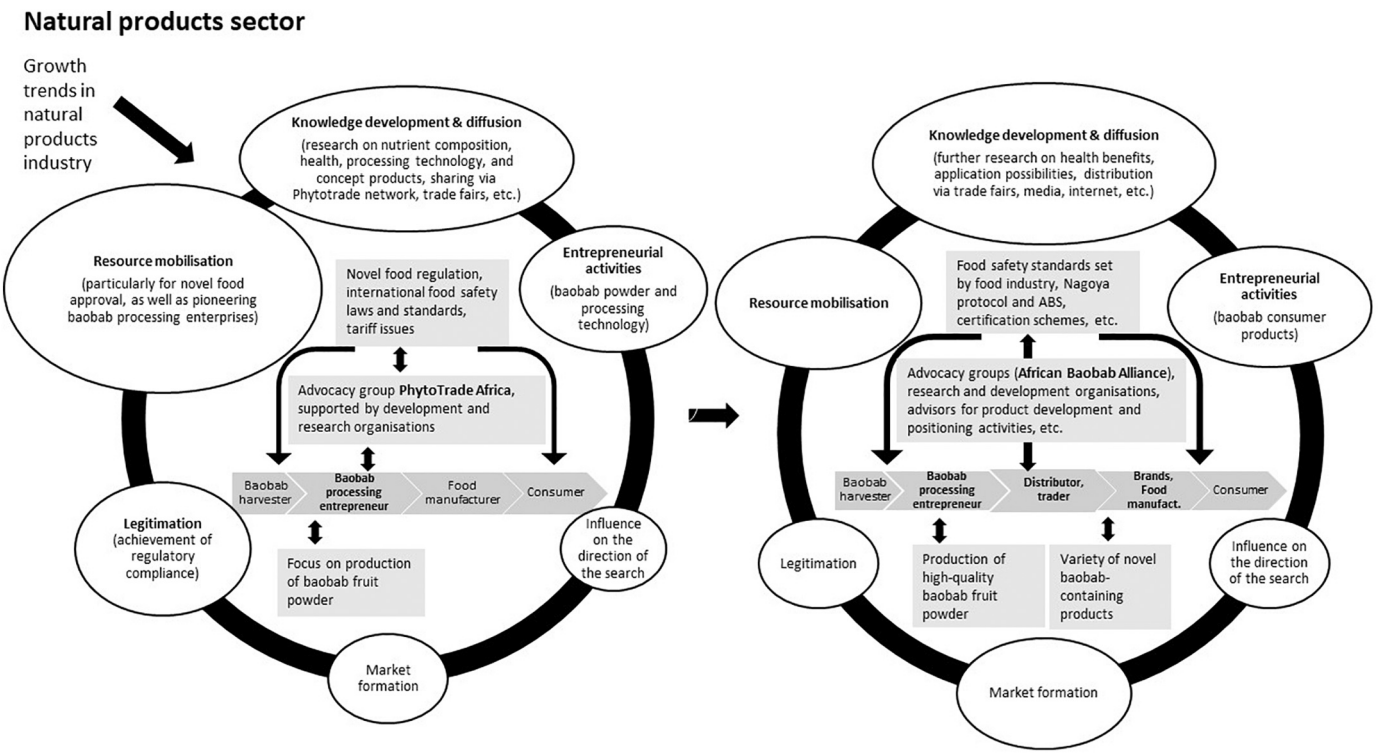

Fig. 2. Overall baobab TIS development framework considering the early phase (left) and the time after the novel food approval has been obtained (right). The size of the system functions corresponds to the frequency these factors were mentioned during the interviews positively influencing the system. Table 2 provides more information concerning the specific topics highlighted.

demonstrated that this can be an important income source for smallholders (Venter and Witkowski, 2013b). Nevertheless, it has been suggested that export may undermine subsistence use, particularly in countries with high levels of traditional utilisation (Buchmann et al., 2010), or that the increasing formalisation can lead to exclusion of smallholders and elite capture (Wynberg et al., 2015).

Against this background, efforts have been made in the export-oriented baobab industry aiming to ensure the trade is conducted in a sustainable and ethical fashion. In this connection, the pioneering stakeholders involved, many of which having a background in development aid, had a probably more important role compared to prevailing regulatory frameworks. PhytoTrade members, committed to social and environmental sustainability principles, integrated activities such as inventory of the resource base and estimation of surplus production capacity, setting of harvesting quotas, establishment of sustainable harvesting guidelines, trainings and awareness programs for harvesters, tree planting activities, or the formation of harvester groups and managed/guaranteed fruit purchase, amongst others, in their respective supply chains – with many such activities still being pursued today despite the demise of PhytoTrade. Certification programs also play major roles for exported baobab fruit powder, although existing standards may not always represent the special nature of NTFPs in an ideal way and can generally constitute a barrier for small-scale producers due to their costs (Welford and Le Breton, 2008). Nevertheless, to date the majority of exported baobab is organically certified, which is associated with training on sustainable harvesting. Different fair trade certification schemes are also relatively common for baobab products on export markets, yet less prevalent than organic. Impact of national regulatory frameworks in the producer countries aimed at increased sustainability, e.g. via regulating access rights or arrangement of harvesting permits, are difficult to assess, due to vast differences across countries in applicable regulations as well as their enforcement. In Zimbabwe, for example, regulations aimed at curbing overharvesting led to unintended consequences such as further marginalization of poor communities and increased corruption, without observable positive impacts on the resource base (Wynberg et al., 2015). Internationally, the Nagoya-Protocol and associated access and benefit sharing agreements intended to regulate bioprospecting are gaining importance, yet have also been associated with elite capture (Wynberg et al., 2015). Differences in regulations and implementation of these across baobab producing countries can give buyers the possibility to shop around for baobab resources associated with the least regulatory restrictions.

Overall, although sustainability considerations have been under consideration from its early beginning in the export-oriented baobab sector, there is a perceived risk that these may become undermined in the future. Increasing demand for baobab resources and more mainstream market participants entering may push the market to focus solely on aspects of price and quality, with less considerations on social and environmental aspects. Thus, activities by interest groups such as the ABA or consumer pressure demanding ethical sourcing are needed to ensure that ethical bio-trade principles remain at heart of the export-oriented baobab sector to differentiate the market.

5. Discussion

Although the high-end baobab industry is still relatively young with international Western markets open for less than 15 years, it has already come a long way. Export levels of baobab fruit powder have in a timeframe of approx. 20 years risen from basically zero to several hundred tons per year. Different technologies as well as supply chain modifications have been developed to be able to comply with the high quality standards demanded in these markets, as well as a variety of certifications, most prominently organic. Numerous value-added products containing baobab have been developed, increasingly also for local markets in the producer countries where demand is expected to rise sharply. Although the high-end baobab sector can overall still be regarded an early adopter market with products targeting predominantly niche markets for healthy, sustainably-sourced foods, it has increasingly

Table 2
Identified major inducing and inhibiting factors in the high-end baobab sector corresponding to system functions.

System function (SF)*	Contributing factors		Hindering factors, blockages	
	Frequency SF indicated	Main phenomena	Frequency SF indicated	Main phenomena
Knowledge development and diffusion	54	– Different research activities concerning baobab, such as investigations into its nutritional value, health implications, or ecological aspects – Technology development (e.g. baobab processing machines) and NPD, leading to new (functional) food products – Sharing of knowledge e.g. via conferences and trade fairs, PhytoTrade network, awareness campaigns, etc.	19	– Limited financial/human resources amongst involved enterprises for R&D and to spread generated knowledge (e.g. on new application possibilities) – Remaining knowledge gaps, e.g. concerning health implications due to baobab consumption (particularly concerning gut health), pan-African baobab resource base assessment, or further product application possibilities – Knowledge dissemination not coordinated, particularly after demise of PhytoTrade
Entrepreneurial activities	23	– Often passionate individuals behind the increasing number of enterprises processing and utilising baobab – Steady experimentation with baobab processing technology, supply chain configuration, etc.	26	– High financial risk for entrepreneur baobab producers, e.g. high levels of pre-financing necessary, cash-flow issues since small-scale harvesters need to be paid in cash – Exacerbated by difficult business environment in Africa (e.g. SME support, general infrastructure)
Influence on the direction of the search	9	– Changing preferences in society (trend towards natural, healthy, ethically sourced food) – Growth anticipated in the sector by baobab producers – Interest rising amongst (mainstream) food manufacturers on using baobab as an ingredient	16	– Standards set by Western markets (e.g. concerning certification, quality) can yet act as trade barrier – Sector currently not differentiated sufficiently by quality/ethical standards; – Consumer awareness often still relatively low
Market formation	16	– Increased awareness and demand for baobab generated via broad mix of marketing activities (e.g. trade show participation, PR campaigns, partnerships with food industry, etc.); supported by trend for natural, healthy food	16	– No demand at onset, regulatory approval for EU/US markets coincided with global financial crisis; demand did not expand as rapidly as expected – Continuous marketing efforts required, due to remaining uncertainties amongst potential customers (food manufacturers) and consumers on applicability of baobab
Legitimation	18	– Advocacy activities e.g. via PhytoTrade Africa or the ABA, concerted effort to make baobab next superfood – Achievement of regulatory compliance (Novel food approval EU, GRAS approval US) – Achievement of standards demanded in Western markets, e.g. concerning organic certification or food quality standards – Rules of the game on exporting to US/EU markets now well established	19	– Resource limitation of advocacy groups such as ABA, demise of PhytoTrade – Regulatory hurdles remaining, e.g. to access novel markets such as China – Differences in regulatory framework across countries e.g. concerning Nagoya Protocol or national regulations – Attaining highest food quality and safety standards demanded by mainstream food manufacturers yet difficult to achieve
Resource mobilisation	31	– Various grant funding support, e.g. for PhytoTrade (most prominently IFAD) or baobab producer enterprises directly – Grants from trade promotion programmes (e.g. CBI or SIPPO), to participate in trade fairs – Mobilising of human resources, formation of ABA bringing industry stakeholders together	30	– Unfavourable business environment in sub-Saharan Africa for NTFP start-ups – Lack of adequately trained personnel e.g. concerning food manufacturing/hygiene – Overall infrastructure can be challenging (e.g. concerning transport, electricity or accessible laboratories for sample analysis) – Lack of resources going into marketing efforts to stimulate demand (production-side prioritised)

* Adapted from Bergek et al. (2008) and Hekkert et al. (2007).

motivated enterprises, other market participants, as well as development organisations to enter the scene.

Thus, overall, baobab has managed to overcome many of the typical challenges associated with NTFP commercialisation. To tackle the generally challenging business environment for NTFPs, including aspects such as inadequate access to financial or human resources, poor infrastructure such as transport networks or electricity supply, and non-supportive institutional frameworks (Meinhold and Darr, 2019), it was, as for other NTFP innovations (Weiss et al., 2017), necessary to develop the sector bottom-up using external support. Financial constraints and lack of both technical as well as marketing and business knowhow was addressed by support provided by development organisations and advocacy groups. This particularly concerns the development of processes to adhere to increasingly complex food safety and quality standards, which often act as a major burden for small food enterprises from the global South and discourage investments in their supply chains and market development (Hermann, 2009; Trienekens and Zuurbier, 2008). Stringent quality requirements have, for example, been shown to threaten the Brazil nut sector (Coslovsky, 2014; Newing and Harrop, 2000), the only globally traded edible seed currently collected from the wild by forest-based harvesters and for which equitable extraction systems could be realised (Guariguata et al., 2017). Such challenges were overcome in the baobab sector via complex interactions of a variety of actors and institutions, both in the global South and the global North. In this connection particularly the collaboration amongst industry stakeholders, donor support from development agencies and, most prominently, the role of the trade association PhytoTrade has to be highlighted, who facilitated the necessary novel foods approval for baobab fruit pulp before exports into the EU and US could commence, costs of which are estimated at close to half a million USD. Furthermore, the role of involved entrepreneurs and their continuous efforts to improve the production process and generate much needed hands-on knowledge e.g. on processing technology or organisation of the baobab supply in order to adhere to aforementioned standards needs to be emphasized. As such, also the common constraint of NTFP commercialisation in the sense of a lacking attention to quality (Cunningham et al., 2017) has been avoided. Entrepreneurs have been shown to be key in shaping other NTFP value chains as well (te Velde et al., 2006), yet

this does not occur in a vacuum (Ludvig et al., 2016), it has to be acknowledged that interactions of a multitude of actors in a respective socioeconomic framework were necessary to facilitate the jump of baobab from rural Africa to Western supermarket shelves. Concerning the challenge of creating sufficient demand and markets – which is often one of the most prominent factors limiting NTFP commercialisation (Marshall et al., 2003) – successful uptake of baobab products in Western markets was also only possible due to the combined and continuous efforts by a variety of stakeholders, including baobab producers, distributors, food manufacturers, brands, PhytoTrade, or trade promotion programmes conducting a variety of activities aimed at creating demand and awareness in the target countries such as trade show participation, PR campaigns, or collaboration with food manufacturers. The relatively close cooperation between different value chain members and building of partnerships between these helped keeping market fluctuations and the risk of creating a boom-bust cycle at bay, although they could not be completely avoided. These developments were further aided by fulfilled regulatory requirements and met consumer expectations in terms of product quality and perceived additional benefits, underpinned by academic research into baobab nutritional value and possible health implications (e.g. Braca et al. (2018) or Coe et al. (2013)), and the general trend towards natural, healthy foods (Grunert, 2017). These findings confirm that market development is a complex process (Sprong et al., 2021), with repeated engagement of both public and private actors in a multitude of activities necessary to shape markets (Ottosson et al., 2020). Challenges concerning lacking or bureaucratically enforced NTFP regulations in producer countries (Tieguhong et al., 2015), which can often also inhibit successful NTFP commercialisation, overall did not feature strongly in the baobab case, with often only little involvement of the state present. Finally, baobab was also helped by the fact that it features a vast resource base, particularly in Southern African countries, fruit harvesting activities are non-destructive, and pioneering producers emphasized sustainable harvesting practises and resource assessments.

However, considering its future development, there is a need for continuous support for the baobab sector as well as a close monitoring of ongoing developments and their impact on the resource base as well as associated communities. International high-end baobab commercialisation may well currently be at a crossroads, with different future baobab commodification pathways possible. These include inter alia a continuous focus on certified niche markets, a progression into responsible mass market, or unregulated mass markets focussing solely on price and quality, typically being main issues for larger food manufacturing enterprises at the expense of ethical supply chains. Furthermore, expanding local markets for baobab need to be considered, and how synergies between these different types of markets can best be harnessed. Opportunities in local markets are often overlooked (Shackleton et al., 2007), yet, nevertheless, also here the same standards should hold as for high-end niche export markets, not only in terms of product quality but ideally also concerning environmental standards and fair trade principles. The needs for e.g. sustainable harvesting practices and proper inventory of stocks, support of conservation activities, adequate payment and training for harvesters, or mechanisms to ensure subsistence use is not undermined have frequently been highlighted (Buchmann et al., 2010; (Meinhold and Darr, 2019); Newton, 2008; Shackleton and Pandey, 2014) to assure environmental sustainability as well as adequate benefit distribution to the local communities where the resource is situated. With such processes having been under consideration from the sector's inception and much knowledge along these lines already available, there is perhaps a stronger need now to raise consumer and food manufacturers' awareness along these lines.

This is of particular relevance since experiences from other internationally commercialised NTFPs have shown that unintended environmental consequences can easily occur or they did not achieve the anticipated benefits for local livelihoods. For example, the analysis of argan oil commercialisation, which was heavily promoted by the Moroccan government and development organisations to boost the economy and stimulate integration of marginalised groups (Perry, 2020), demonstrated at least questionable impacts on overall local development and poverty reduction (Le Waroux and Lambin, 2013; Lybbert et al., 2002; Perry, 2020) as well as negative implications on the argan forests (Lybbert et al., 2011). Shea from Western Africa, where trade to the global North already started in colonial times with nowadays more than 90% ending in foreign markets, predominantly the chocolate and cosmetics industries (Bello-Bravo et al., 2015), has been shown to be an important income source for women (Pouliot, 2012). However, the majority of shea is cheaply bought from women pickers as unprocessed kernels at source and sold via middlemen to processing plants serving the food industry, although some closely integrated supply chains working with women cooperatives exist, particularly for high-end cosmetic purposes (Bello-Bravo et al., 2015). Overall, considering the considerable investments and efforts necessary to develop equitable international NTFP supply chains it has to be acknowledged that such approaches will most likely not be feasible for all potential NTFPs, but only selected species - characterised e.g. by a thorough understanding of the supply chain, abundant natural resource base, participation of visionary champions, particular attention to quality and upgrading, strategic use of branding and certifications, strategic partnerships and regional co-operation, as well as donor support (Cunningham, 2011).

6. Conclusion and recommendations

Despite being a low-tech sector originating in sub-Saharan Africa, the development of the high-end baobab industry shows many similarities typical for emerging industries. The rising demand for natural, healthy foods triggered an increasing number of enterprises, supported by developmental organisations, to identify and take up commercial opportunities and foster a variety of innovations transforming the use of baobab from a solely informally used product to a global superfood. To overcome weak innovation systems in the producer countries and typical barriers to NTFP commercialisation, a bottom up approach and complex interactions amongst a multitude of actors and institutions across the globe were necessary. In the initial phases it was particularly important to create the needed legitimacy via mobilisation of sufficient financial and human resources and generate much needed knowledge on the resource, its supply chain, processing steps, amongst others. Simultaneously, activities aimed at stimulating demand for the resource in Western markets have been included early on, yet a stronger focus should be set here in future to ensure the sustainability of the sector.

This particularly refers to increasing awareness on sustainably-sourced baobab amongst consumers and food manufacturers. With the knowhow of producing high-quality baobab now more readily available, the sector now needs to differentiate more clearly especially in terms of environmental sustainability and ethical supply chains. With all baobab resources currently stemming from rural smallholder producers, activities focusing on increasing demand and raising awareness for sustainably-sourced baobab in the global North may well have higher developmental impact than direct efforts in the supplier countries. Furthermore, there is a continuous need for actions to help preserve the resource base, ensure ethical supply chains e.g. via certification mechanisms, and more clear, harmonized, and effectively enforced regulatory frameworks. Important research gaps remain, particularly concerning a thorough assessment of the resource base on a pan-African level to better understand the overall capacity, potential health benefits of baobab fruit powder or further possible applications. Such issues cannot be tackled by cash-constrained NTFP enterprises or advocacy groups such as the African Baobab Alliance with limited resources alone, calling for further public support for the developing sector.

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CRediT authorship contribution statement

Kathrin Meinhold: Conceptualization, Methodology, Investigation, Data curation, Formal analysis, Validation, Writing – original draft. **William Kwadwo Dumenu:** Methodology, Investigation, Validation, Writing – review & editing. **Dietrich Darr:** Conceptualization, Methodology, Validation, Writing – review & editing, Supervision.

Declaration of Competing Interest

The authors declare no conflict of interest.

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