



## Research article

## Integrating endemic medicinal plants into the global value chains: the ecological degradation challenges and opportunities

Tom Volenzo<sup>\*</sup>, John Odiyo*School of Environmental Sciences, University of Venda, Private Bag X5050 Thohoyandou 0950, South Africa*

## ARTICLE INFO

## Keywords:

Collective action  
 Common property resources  
 Biopiracy  
 Ecosystem sustainability  
 Bio-prospecting  
 Natural resource management  
 Institutions  
 Property rights  
 Value chain  
 Pharmaceutical science  
 Ecology

## ABSTRACT

Though innovations for sustainable management of natural resources have emerged over time, the rising demand for nature based health solutions and integration of endemic flora into global value chains could have adverse impacts on ecosystems. The ecological risks in the exploitation of the wild endemic medicinal plant resources are exacerbated by a myriad of agrotechnological risks and challenges that highly constrain their domestication. Successful exploitation and commercialisation of medicinal plants thus require a clear understanding of their demand and production systems or value chain analysis. Accordingly there is need for innovative approaches towards their integration into global value chains. Since quality and safety, traceability, certification, as well as consumer tastes and preferences are critical drivers in purchasing decisions by global consumers, they are inadvertently exploited to weaken Indigenous knowledge (IK), undermine common property rights and entrench value chains that favour a few elite buyers. This tend to create pervasive incentives for overexploitation of medicinal plant resources and environmental degradation. Potential solution lies in the recognition of drivers of vulnerability to environmental degradation and the innovative use of policy bricolage, feedback loops and interactions between knowledge, power and agency on one hand, and collective action and property rights institutions on the other hand. We conceptualise a framework that can mediate a transformational agenda and enhance systematic understanding of sustainability lenses in endemic medicinal plant resources value chains. This could strengthen IK, enhance collective action and promote participation of local actors with positive impact on the utilisation and integration of endemic medicinal plant resources into global value chains.

## 1. Introduction

Natural resources capital plays a critical role in provisioning of food, freshwater, fuel wood, ecosystem services, such as climate change regulation and non-material benefits such as sense of place, aesthetics, recreation and spiritual services [1]. Natural resource management is thus a complex socio-political system concerning how local and non-local actors engage to pursue their values around environmental systems, negotiate rights and arrive at a workable model of collective action across scale [2]. The coupled and co-evolving human-environment have implications for uncertainty and prediction of policy outcomes [3]. In the integration of medicinal plants into the global value chain, the challenge lies in finding synergy between environmental sustainability objectives amidst value, cultural and institutional divergences. This raises the need for complimentary action among the multiple actors, as well as close attention on how to integrate the multiple dimensions of sustainability.

Transformational agenda seeks to address the root cause of vulnerability by introducing fundamental changes to attributes of a system [4]. In essence, pursuit of transformational agenda involves rethinking and reframing of policy and practice, engaging multiple knowledges, as well as questioning subjectivities inherent in discourses and problem understanding. Such analytical frameworks need to be inclusive of individual, community, state and non-state actors' interests, aspirations and interactions.

In spite of increasing international trade in medicinal plants, benefits to developing countries, particularly to growers and producers, remain low. This is attributed to intermediaries, as well as lack of organisation and networking by the poor collectors of medicinal plants from the wild. This increases transactional costs, a constraint exacerbated by increasing stringent health and safety requirements in the main developed country markets [5]. In essence, stringent health and safety requirements act as non-tariff barriers to market entry and full participation in the value chain by majority of the developing countries. For example, the European

<sup>\*</sup> Corresponding author.

E-mail address: [volenztom@gmail.com](mailto:volenztom@gmail.com) (T. Volenzo).

Union directive 2001/83/EC [6], requires provision of extensive documentation of physicochemical, biological and microbiological, as well as the pharmacological and toxicological tests and results of clinical trials as proof of its quality, safety and efficacy before placing plant based medicinal product on consumer shelves. Though some exemptions on the scope of needed documentation are provided for clinically proven products (directive 2001/83/EC; European Union, 2004), such exemptions only apply to EU member countries.

The importance of medicinal plants in the provision of health care is critical in many countries [7]. For example, 80% of the South African population use traditional medicine to meet their primary health care needs, with the diverse genetic base of medicinal plants offering opportunity for bio-prospecting [8]. Though the use of medicinal plants is not a new phenomenon in several parts of the World, there has been an increase in international and local screening initiatives to identify pharmacologically active from medicinal plants [8, 9]. This is also reflected in medicinal commodities global value chain. Currently, the global trade value of medicinal and aromatic plants (MAPs) is US\$800 million per year and projected to grow at a rate of 15–25%, with an estimated value of US\$ 50 trillion by 2050 [10]. According to [7], 35,000 to 70,000 plant species have been used so far as medicaments. This corresponds to 14–28% of the 250,000 plant species estimated to occur around the world. Table (1) provide some statistics [10], on the value and trends in the global value chain of Medicinal and aromatic plants (MAPs). The figures depict various trajectories in the global medicinal value chain. While exports of medicinal plants by China between 2000 and 2015 grew 8 fold, the imports decreased by 25%. This is attributed to policy initiatives in incentivising local production, domestication and cooperative marketing of medicinal plants. For German, exports grew two-fold while imports grew fourfold in the same period suggesting expanding domestic consumption and its strategic position as a leading commercial hub in Europe. Lack of data from African countries could be as a result of poor traceability mechanisms.

Commercialisation of medicinal plants normally follows bio-prospecting and patenting trajectories [11]. Bioprospecting involves the assessment genetic, biochemical properties and commercial viability of biological material [8, 11, 12]. This has prompted the government of South Africa to identify and place medicinal plants as part of biodiversity

economy while empowering local communities that grow and sell medicinal plant species [13].

Bio-prospecting is to a great extent anchored on indigenous knowledge systems and the institutions of collective action [11]. In most cases, the isolation of active pharmacological agents in bioprospection is patented and commercialised. However, commercialisation and patenting are often guided by policy discourses that conflict with existing customary rights on access, use and control of medicinal plant resources. Literature suggest that bioprospecting and subsequent commercialisation of medicinal plants has mixed outcomes in Africa and other parts of the world [14, 15]. For example, the increased vulnerability to extinction of a number of endemic medicinal flora, such as African ginger (*Hypoxis hemerocallidea*) in South Africa is attributed to high demand, destructive harvesting practices and inherent slow growth of such species [15, 16].

Integration of traditional medicinal plants into global value chain could negatively impact plant genetic resource base and ecological sustainability at large. Since environmental vulnerability is shaped by the ability to access resources across time, space and across actors, there is need for innovative approaches in the commercialisation of medicinal plants. Peterson and David [17], define an endemic species in terms of the spatial spread and the degree to which the reference plant or animal taxa survival and growth is restricted in a given landscape such as a country, mountain range, riverine ecology, latitude, soil type or reserves within a region or a country. In this article we define endemic medicinal plants as plant taxa whose survival, expression of target metabolites (active ingredients) for production of plant derived pharmaceutical products and domestication is highly restricted to specific landscapes, such as high altitude montane areas of a country or a region. The slow growth, an underlying risk in ecological degradation is characteristic of such plant taxa.

Our main contribution through this article is in resolving existing policy practice gaps on commercialisation of medicinal flora and paucity on pragmatic policies that guide the exploitation of threatened endemic plant species [15]. We thus examine the concept of property rights and collective action and the closely related triumvirate of knowledge, power and subjectivity to unpack human-environment interactions and their potential impacts in medicinal value chains. We further attempt at closing existing gaps on the role of institutional and environmental economic, and its utility in the exploitation and integration of medicinal

**Table 1.** The world's leading countries in the import and export of commodity group plants, 2000–2015.

Country/Year	Exports (Tons)	Value (USDD)	Import (Tons)	Value (USDD)	
India	2000	45,187.824	67,424,8696	8,686.318	6,365,901
	2005	50,946,308	76,755,108	15,265.486	18,973,429
	2010	NA	132,509,661	34,183.084	63,171,398
	2015	87,587.587	237,314,783	29,216.631	69,215,419
USA	2000	NA	107,996,131	NA	132,521,409
	2005	NA	89,539,431	NA	188,356,062
	2010	NA	143,747,758	NA	267,650,602
	2015	NA	140,052,464	NA	393,622,808
Germany	2000	14,281.148	55,506,000	44,237.783	87,130,000
	2005	15,943.254	84,673,000	49,095.617	120,137,000
	2010	18,951.933	120,600,363	56,722.995	191,916,650
	2015	22,838.952	152,143,717	64,357.283	247,954,969
China	2000	20,904.936	39,391,365	186,437.287	216,525,952
	2005	204,834.620	286,127,132	36,204.572	32,567,814
	2010	227,037.715	625,130,308	38,053.810	70,943,972
	2015	176,583.767	1,036,615,341	44,913.152	139,313,607
UK	2000	601.382	6,089,464	8576.088	36,305,713
	2005	2401.386	49,987,108	8627.194	1,844,4588
	2010	903.028	15,343,734	9408.422	63,171,398
	2015	1,492.596	32,611,446	10,298.794	61,679,145

Source: UN Comtrade, 2018 [10], Only figures reported in Code HS 1211 (volume basis of various raw material). NA, Not available

plants into the global value chain. We ultimately suggest a conceptual framework with endless possibilities for forecasting and resolving social-policy constraints and conflicts at several interfaces in the bio-prospection and commercialisation of medicinal flora. The conceptual framework from the article, can be used as a tool for reflective planning and Sustainability Impact Assessments in the integration of medicinal flora into global medicinal plants value chains.

## 2. The triumvirate of knowledge, power and subjectivity in natural resource management

Global medicinal plant value chains provide a classic example of coupled Human-Environment (H-E) systems with potential to exacerbate ecological perturbation. H-E interactions are associated with complex problems, as well as the role of human agency on environmental governance and sustainability assessments has gained attention in policy and implementation spaces [18]. We use *prunus africana* and a number of other endemic medicinal plants, to critically examine the coupled interactions in medicinal plant value chain and associated ecological impacts. We thus extrapolate H-E interactions in medicinal value chain from political ecology angle in synthesising existing literature and providing a holistic framework for the assessment of sustainability in global medicinal value chains.

Coupled H-E interactions link institutions and stakeholders to influence environmental change, the choice of risk assessment frameworks used [19], and decision making processes [20]. H-E frameworks such as political ecology thus increase the understanding and resolution of interconnected socioeconomic and environmental sustainability challenges [21], such as the production and management of spillover effects [20, 22]. H-E interactions are mediated by politics and power dynamics that affect governance systems and knowledge of the actors [23]. Political ecology examines motivations, interests, strengths, weaknesses of actors, as well as their relative strength and influence in relation to other actors in environmental governance [24]. As an endemic flora that thrives in limited number of montane ecological niches and one of the most exploited medicinal plants, African cherry (*Prunus africana* (Hook.f) Kalkman (hereafter referred to as *Prunus africana*), a member of Rosacea family [15], offers important lessons on integration of endemic medicinal plant species into the global value chain and the associated ecological risks associated.

Control over natural resources and more so over land, is an important means by which people stake and maintain claims to social and political power. For example, the elite domination in natural resource exploitation can be extended by offering pervasive money making incentives to the poor and which have negative consequences, such as, cutting of green wood and harvesting out of season or in prohibited areas [25]. Understanding the triumvirate of knowledge, power and subjectivity is thus critical in transformative initiatives in natural resource management.

Attention to ecological risks is critical in the sustainable exploitation of medicinal plant species. Though the nexus model is critical in the identification of relationships and interdependencies in environmental resource management, it fails to explain how risk and behaviour, compromise and negotiation can be achieved in creating the interdependencies at planning and policy phases [26]. The shortcoming in the nexus approach thus fails to fully address social-policy dilemmas. We contextualise this in the following section by exploring the triumvirate of Knowledge, power and subjectivity and their potential to mediate or constrain Natural Resource Management outcomes.

Power relations connote strategies by which people or political class try to direct and control the conduct of others. This is exercised through allocation and control of resources [27]. Authority and knowledge are thus self-reinforcing phenomena. Authority is either legitimised, reinforced or challenged through use of knowledge [4]. In the same manner, knowledge claims may be a source of legitimacy and power. In this way power is equated to influence [25].

Subjects are cognitive attributes defined by position of individuals in a social system, such as medicinal value chain. Practices, discourses, policies and actions define subjects around which actors assert their agenda and protect their interests in face of social and environmental change [4]. Discourses may for example legitimise particular knowledge and subjectivities. The discourses with less formal local institutions are critical vehicles for contestation within and between institutions and interactions between localities and larger scale institutions [25].

Authority draws from formalized institutions and organizations at different scales, legitimacy and claims to make decisions about environmental governance, as well as, informal institutions claims over resource governance [4]. The intertwining of productive and repressive aspects of power is key to understanding the relationship between power, subjectivity and agency [27]. Power can thus be enacted either as a tool for domination or emancipation [27, 28], with consequences on social differentiation [29].

Power broadly refers to processes through which individuals and collectives cooperate and collude in order to govern their affairs [30]. Authority captures competition for influence and ability to exert agendas by one individual or an institution over the other [31]. This is significant in that actors with significant presence and clout in public and private spheres may have greater opportunities to help bias the parameters of decision making to their benefit [32], or between different social groups. Biased decision making may in turn result in lost opportunities and mis-characterisation of the underlying risks [33]. The enactment of power could thus have negative or positive outcomes on livelihoods [4]. The foregoing is critical in frameworks that attempt to link value chains and environmental vulnerability assessments.

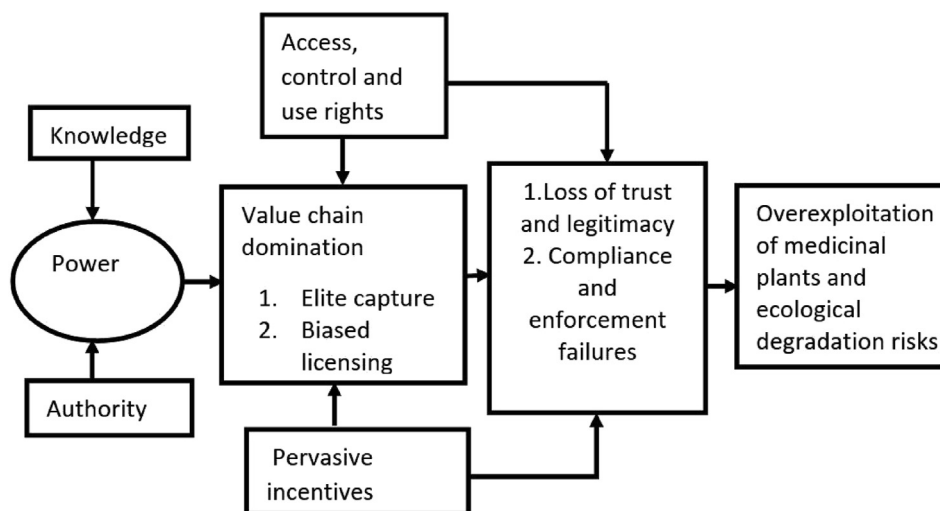
The centrality of compliance and conflict is critical in the analysis of risks and opportunities from increasing markets for natural products, such as the integration of endemic medicinal plants into the global value chains. In extending this argument, we review institutional frameworks in natural resource management, the global medicinal plant value chain and how these are impacted by the triumvirate of knowledge, power and subjectivity. The interaction of authority (power), knowledge and subjectivity [4], is given in Figure (1). The framework is in the next section adapted to extend our argument about institutional frameworks in Natural Resource management in general and Common Property Resources (CPRs), such as medicinal plants in particular.

## 3. Institutional frameworks, property rights and sustainability in natural resource management

Institutions are the rules, values and practices that guide formal and informal organisations [34]. Institutions consist of both informal constraints (sanctions, taboos, customs, traditions, and codes of conduct), and formal rules (constitutions, laws, property rights). Together with the standard constraints of economics, they define the choice set that determine transaction and production costs, as well as the financial feasibility and profitability of engaging in an economic activity [35].

Various collection of institutions constitute governance systems. This include interactions between different centres of power in society (corporate, customary-law based, governmental, judicial) at different scales from local through to global level [36]. Institutions and governance systems determine, to various degree, the access to, and the control, allocation and distribution of components of nature and anthropogenic assets and their benefits to people. Examples of institutions are systems of property and access rights to land (e.g. public, common-pool or private), legislative arrangements, treaties, customary laws, informal social norms and rules, and international regimes agreements.

The bundle of entitlements that define ownership, privileges and limitation for use of a resource, collectively referred to as property rights (PRs), shape the pattern of use and motivation for sustainable strategies, as well as benefit sharing. From institutional perspective, PRs, is synonymous with the capacity to call others/collectives to stand behind ones'



**Figure 1.** The triumvirate of Power, Knowledge and Authority in Medicinal plant value chain and ecological degradation (adapted from Eriksen, Nightingale, and Eakin, 2015 [4]). In most medicinal value chains Power is embedded in privileged market intelligence and information differentials and governance frameworks that facilitate elite capture.

claim to a benefit stream and claim [37]. Examining such entitlements and how they are exercised could provide an understanding of related environmental risks, how such risks arise and mechanisms for reforms in the mitigation of the risks.

In a judicial and administrative setting, de jure rights are lawfully recognised as formal legal instruments. Defacto rights on the other hand occur where resource users cooperate to define and enforce rights among themselves [38]. A conglomeration of de jure and defacto property rights, however, may be in existence to compliment, overlap or conflict with one another. In many situations, de jure authorised users or claimant rights and defacto proprietor arrangements which are understood, followed and perceived as legitimate within the local community emerge [39].

The effect of resource characteristics, characteristics of resource users, economic, political and legal, as well as technological factors on CPR are given by [40], as universality, enforceability, transferability and excludability. Exclusion (excludability) rights bundles determine who has access right while alienation (transferability) rights bundles signifies the right to, temporarily or permanently transfer, sell or lease or both. Universality refers to completely specified rights, privileges and limitations, excludability is used in relation to benefits and costs associated with ownership and use of the resource that directly or indirectly accrues to the owner.

Universality, enforceability, transferability and excludability factors are thus critical in the analysis of how knowledge, power and subjectivity interact and influence resource use outcomes. According to economic theory, if appropriate PR systems could be defined over all natural resources with little or no transaction costs, then different stakeholders might be able to make solutions to the environmental problems [41]. Acknowledgement of the embedded externalities, as a problem in natural resource use, require negotiating mutually beneficial solutions and forging strong sense of community responsibility and collective action [42].

Natural resource management is vulnerable to institutional failures [43]. The institutional failure challenges are partly accounted for by failure to consider social and environmental contexts in which community participation is embedded [2]. The institutional failures are thus fueled through competition, collusion and conflict, as well as policy discourses that cement rationalities and promote particular regimes of governance [4]. This includes selective legitimization of strategic interests of actors, such as development agencies, state organisations and dominant market players [44]. This is critical in analysis of medicinal value chains where community actions are increasingly being shaped by

outside forces rather than locally initiated collective action [45]. We extend the view in the next section in examining design challenges and some policy failures in CPRs.

Promoting incentive structures that are less vulnerable to short term interest and meeting long term ecosystem scale objectives in a cost effective way is one of the design challenge in CPR and collective action [38]. Accordingly there is need to analyse the role of knowledge, power and agency and how they are mediated for sustainable outcomes under complex interrelations, such as those that involve property rights and collective action, moreso in natural resource ownership discourses.

The various forms of natural resource ownership are Open access resource (OPR) and CPR [34]. Under (OPR) ownership, no limit is placed on who can appropriate a given resource and no appropriator has any incentive to leave any resource unit for other appropriators [46, 47]. In theory, alienation through privatization permits a resource to be shifted from a less productive to more productive use [46]. However, in practice there are many cases in which privatisation and/or challenging of CPR has resulted into resource degradation.

In natural resource management, over investment directly or indirectly increases vulnerability to resource degradation traps and consequently the loss of genetic and biological resources [48]. Over investment is symptomatic of profit maximisation rationale under free market and privatisation scenarios. Over investment and rent dissipation of the fishery resources is illustrative of ecological risks when CPR institutions are undermined or challenged. For example, the hitherto efficient defacto property rights and collective action over the rich fishery resources around Valenca, Brazil crumbled following the overharvesting and depletion of fishery resources following the enactment and prioritisation of de jure rules over defacto rules [46]. Since global medicinal value chains to a greater extent rely on the extensive collection of wildings, there is need to focus on property rights, indigenous knowledge (IK) and the closely related role of collective action in the mitigation of the inherent ecological risks.

#### 4. Community as an institution in natural resource management

In Natural Resource Management discourses, communities are viewed from different analytical lenses such as the spatial and Institutional model. Under the spatial model lenses, a community is defined as a geographically bound entity with strong bonding and interactions taking place within the spatial boundary. The institutional model [49], conceptualises a community as spatially fixed, use rule based collective



action entity that has interactions across spatial boundaries. Under the delocalised community model scale [2], a community is conceptualised as an entity that is concurrently embedded in both local, regional and global networking. Though global value chains are critical drivers in delocalisation processes, there exists opposing scholarly views on the impact of delocalisation on natural resources management outcomes.

On one hand, delocalisation processes is perceived to create pervasive incentives for environmental degradation, depress innovation and/or conflict of interest over use, access and control [4]. On the other hand, "Localisation" or exclusion of external actors and the associated dynamics can undermine the development of inclusive, productive, innovative and democratic local institutions [31]. Most of the foregoing findings have been based on timber based forest products. However, studies on bio prospecting, commercialisation and delocalisation of Non-timber forest products, such as medicinal plants, seem to suggest that delocalisation has adverse impacts on biological and genetic resources. The negative impact seem to be associated with the undermining of indigenous PRs and institutions of collective action [40].

In assessing environmental vulnerability, the most relevant operational level PRs are access and withdrawal rights. This has close relation with the problem of appropriation, maintaining the resource stock, resource flow, rent dissipation and conflict over assignment of rights. Rents are dissipated whenever many individuals are allowed to withdraw more than the economically optimal quantity of resource unit which in turn reduces (increases) the marginal returns (costs) to the operators [50].

According to [34], excludability creates and sustains effective collective action (i.e. use of taboos, norms and values) in the management of CPRs, such as medicinal plants. Participatory formulation and implementation of decisions concerning environmental resources, a form of collective action, is among the sustainable solutions on governance with complex environmental challenges [50]. This includes mechanisms for controlling access and appropriation or excludability. Collective action is enhanced when PRs and the institution for its enforcement are neither challenged nor undermined [51].

## 5. Challenges and potential solutions in medicinal plant value chains

Successful commercialisation requires a clear understanding of the demand and production systems of medicinal plants and their value chain. A value chain includes the full range of activities that are necessary to avail a product from its origin to an end user in a form that satisfies her/his needs, tastes and preferences [52, 53]. The critical activities in the value chain include research, production, transportation/distribution, processing and trading, warehousing/storage activities geared towards meeting end users' needs and preferences. Value chain analysis is thus one of the most useful tools for understanding how markets for a particular good, such as plant derived pharmaceuticals operate.

Though few medicinal plants value chain studies have been undertaken, available findings suggest their critical role in the sustainability, equity and safety of herbal medicines [54]. Value chains influence power and dominance among actors (producers, retailers and middlemen) in terms of accrued income, the characteristics of the final product, as well as the competitive advantage of the product over similar products [55, 56]. Value chains thus hold a critical role in the sustainable commercialisation and integration of medicinal plants, such as medicinal wildings.

Middlemen dominated medicinal plant value chains are generally long, unregulated and have a tendency to amplify inequity and inefficiency [57, 58]. In the upstream value chains, capital and skills, volume, quality, and consistency of supply are major bottlenecks, especially in small scale farmers' value chains [59]. Poor availability of market information exacerbates the constraints [57]. The domination by middlemen greatly reduces the margins to farmers and harvesters. It further increases the risk of biopiracy or the patenting and selling plant

derived pharmaceutical products from indigenous plant species without acknowledging or providing financial compensation and/or royalties for the traditional knowledge to the medicinal plant source countries or communities. Figure 2 provides an illustration of atypical global medicinal value chain.

The knowledge held or owned by indigenous people and local communities is the basis for bioprospecting or production of useful products, such as herbal medicine, cosmetics, food flavours and fragrances [11]. Such knowledge may be oral, documented or in other forms. Hence, a rich cultural heritage is relevant in the conservation and sustainable use of biological diversity. Since genetic resources and traditional knowledge are inseparable, its documentation is integral to the conservation of biological diversity. However, medicinal plants are faced by continuous erosion of the IK among many other threats [57], as well as biopiracy [13].

Lack of and/or inadequate governance systems on intellectual property rights in most developing countries increases the vulnerability of their genetic resources to biopiracy [52]. Under Nagoya convention on access to and benefit sharing (ABS) protocol [61], utilisation of genetic resources, research on genetic or biochemical composition of genetic resources, as well as subsequent application and commercialisation of the isolated active ingredients are considered. This partly resolves the ambivalence around difficulties in the definition of biological and genetic resources alluded to by [11]. Though the Nagoya protocol has the potential to strengthen collective action and claims to benefits from bioprospecting of genetic resources, it does not conclusively resolve governance dilemmas on IK and CPRs.

One of the major threats to medicinal plants is the increased loss of genetic diversity due to unsustainable exploitation and loss of habitats. The increased pressure on medicinal flora is fuelled by high and increasing demand for medicinal plants [5, 59]. For example, in a study in Tanzania, the indiscriminate and widespread harvesting of wild medicinal flora was found to have extended into sacred forests which endangered or led to extinction of many plant species [62]. Risks of extinction could negatively impact livelihoods, economies and health especially in communities where medicinal plants are found [12, 62].

Biotechnology and domestication of medicinal plants species are some of the strategies that can be adopted to reverse resource over-exploitation in medicinal plant value chains. The use of molecular marker assisted selection, tissue culture and genetic transformation which alter pathways for biosynthesis of target metabolites thus hold great potential in overcoming constraints such as the slow growth rates characteristic of medicinal plant wildings [63]. However, difficulties in the identification of the right cultivar, uncertainty on level of active ingredients in the domesticated cultivars, pest and disease challenges and low environmental tolerance or survival under cultivation stand out as agrotechnology challenges that constraint the domestication pathways [57]. Domestication of most medicinal plants is further constrained by limited knowledge on management, as well as inadequate basic research effort on the distribution, genetic diversity and ecology of the species [64]. This could be the plausible reason for preference of wildings in the medicinal value chain.

Marketing and promotion of wild plants and their derivative products requires substantial capital investment that can hardly be committed without clear market and value chains information [65]. Value chain dynamics may thus possibly account for dominance of global medicinal value chain by a few countries. According to [66], 80% of international trade on plant derived pharmaceuticals are controlled by 12 countries (Table 2). Dominance by a few value chain actors could create monopolies with negative outcomes on through unfair competition for scarce medicinal plant resources, biopiracy and inadequate compensation for suppliers of medicinal plant resource reinforcing the risk of rent dissipation.

The major sources of risks to commercialisation of medicinal plants through cultivation (domestication) include biopiracy, illegal collection, long gestation period to maturity, unresponsive permit/licencing

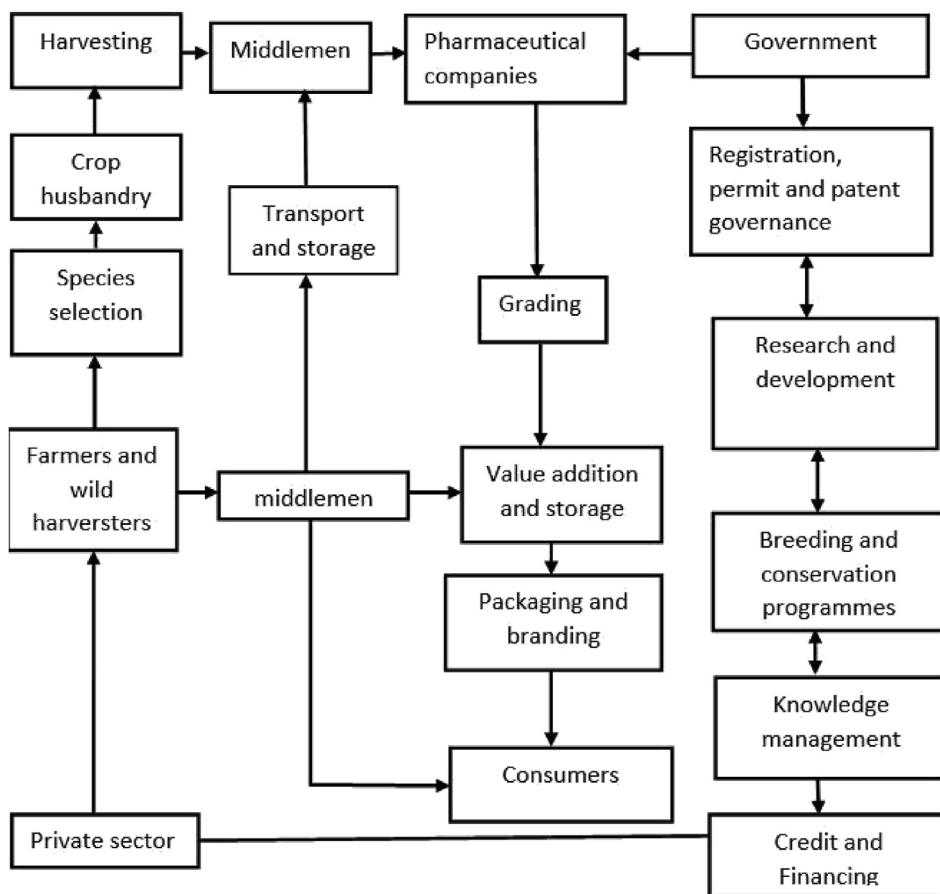


Figure 2. Medicinal Value chain (Adapted from Phondani *et al.*, 2016 [60]). Value chain involves activities such as transport, storage, value addition, transport, packaging and storage. In the global medicinal value chain, middlemen dominate as the local communities are not well organized. The domination of medicinal value chains is thus one of the weak link towards sustainable integration of medicinal plants into global value chains.

Table 2. The world's leading countries in the import and export of commodity group pharmaceutical plants,1991–2003.

Country of import	Tonnes	Value (US\$)	Country of export	Tonnes	Value (US\$)
Hong Kong	67,000	291,200,000	China	147,000	281,800,000
Japan	51,350	136,000,000	Hong Kong	63,150	228,800,000
USA	49,600	135,500,000	India	33,900	56,650,000
Germany	45,350	110,200,000	Germany	15,100	70,050,000
Rep. Korea	32,250	52,300,000	USA	13,500	115,500,000
France	21,350	52,000,000	Mexico	13,000	11,250,000
China	13,650	41,600,000	Egypt	11,750	13,850,000
Italy	11,700	42,850,000	Chile	11,600	28,200,000
Pakistan	11,050	11,150,000	Bulgaria	10,050	14,500,000
Spain	9,100	27,650,000	Singapore	9,600	56,600,000
United Kingdom	7,650	27,000,000	Morocco	8,000	13,300,000
Singapore	6,300	50,600,000	Pakistan	7,800	4,950,000
Total	326,300	978,150,000	Total	344,400	893,400,000

Source: UN COMTRADE database, 2018[10].

systems, dispersed producers and lack of linkages among chain actors [57], as well as poor quality planting material and uneconomic plots adopted by farmers [57, 66]. Additional bottlenecks to field cultivation also include lack of detailed and accurate market information [5, 57, 60]. As some of the medicinal plants are sources of multiple active ingredients in the production of plant based pharmaceutical products, there is high market risks for investors who wish to commit funding to a single plant development, a constraint that is exacerbated by high

preferences for naturally sourced products among consumers which disadvantages processed alternatives in the value chain [63]. This increases preference for wildings as a conventional risk management strategy.

Though Intellectual property rights (IPRs) in the form of copyrights, patents and industrial design protection offer strong protection to creations that are original, novel, and attributable to an individual creator/owner (person or corporation), they systematically exclude products

arising from traditional creativity [67]. Accordingly, under patent law, the synthesis of biochemical compounds is not part of the indigenous medical knowledge [67, 68]. For example, the USA patent law, only recognises prior knowledge, use or invention which occur within USA or is evidenced by accessible publication in the USA [67, 69]. The inherent contradiction weakens IK, promote biopiracy, as well as monopolistic tendencies that negatively impact on international price for the affected plant derived products [69]. Decline in IK thus constrains the development of medicinal plant value chains [5, 57].

The controversy between India and a USA firm (W.R.Grace & Co) on the patenting of products from Neem tree (*Azadirachta indica*) and *Curcuma longa*, commonly known as turmeric [67, 69], is illustrative of the role documentation, biotechnology, a priori information, conflict and compliance to International conventions vis a vis territorial jurisdictions on patents and the diminishing power of indigenous property rights. Though India had for a long time been identified with the IK and processing of an oil based pesticide from the neem tree, it lost the patent contest on the basis that the USA based firm had modified the IK to improve the shelf life of the active ingredients, in itself an intellectual novelty [67]. In contrast, it won the turmeric contest on evidence of extensive documentation of traditional knowledge databases concerning the use of the plant in the treatment of cancer. Documentation of indigenous knowledge alongside research that validates such knowledge (through documentation, clinical and efficacy trials) could thus strengthen IK and reduce biopiracy.

The interplay between indigenous knowledge, biopiracy and weakness of international conventions and national legal frameworks in biopiracy is further illustrated by contested case studies, such as the patenting of chemotherapeutic agent, vinblastine, from rosy periwinkle (*Catharanthus roseus*), a native of Madagascar and Hoodia (*Hoodia gordonii*), a succulent plant used for centuries by indigenous San people of South Africa where precedents on IPR, dominance and power of dominant value chain actors completely overrides IK and CPR. The share of benefits to the San people of South Africa from *Hoodia gordonii* followed the enactment of legislative and policy supportive to IK [68]. However exclusive exploitation of rosy periwinkle by international actors has prevailed due to weak legislative frameworks and pervasive incentives to local communities.

### 5.1. Value chains, commercialisation and ecological degradation risks: the case of *Prunus africana*

Medicinal plants represent part of the natural biodiversity endowment around the world and is essential for human wellbeing in terms of food security, human health, provision of clean air and water, local livelihoods, economic development in addition to being central component of many belief systems, worldviews and identities [13, 64]. In particular, wild medicinal plants are an important source of livelihood for many of the poor people in developing countries [54]. In addition to meeting the requirements of medicine for an increasing human population, plant derived medicines have minimal side effect relative to synthetic medicines [57]. In this section, we use the case on *Prunus africana* to demonstrate how value chains, collective action in a community, power, knowledge, institutions on property rights and ecological degradation interact.

Commercialisation of wild *Prunus africana* in Cameroon is chronicled by [15], in terms of bioprospection trends, commercialisation trajectories, governance and policy failures. Prior to 1972, only small-scale harvesting of *Prunus africana* bark occurred for local medicinal use. This changed dramatically in 1972 when Plantecam, a subsidiary of the French company Laboratories Debat, obtained a monopoly over the commercial trade in *Prunus africana* bark. Although commercial harvesting started to take place, a system of controlled harvest by teams of Plantecam workers was maintained. This worked relatively well until 1985 when the Government of Cameroon issued fifty additional licenses, in essence liberation and the emergence of free

market regime in the exploitation of *P. africana* bark. However, the licensing of additional entrepreneurs was not based on any forest inventories or assessments of sustainable harvest technologies [15]. The adoption of a free market model created pervasive incentives among suppliers (middlemen and local individual harvesters) and buyers. Since no incentives for seeking or maintaining stocks in their area were in place, increasing the number of permittees by default transformed CPR into an open access resource.

As the wild populations were the sole source of the bark, the increase in number of licenses, had a devastating effect including depletion of the wild populations in West and North West regions. The overexploitation became especially serious in 1994, when the Cameroonian government ended Plantecom's monopoly over bark harvest on Mt. Cameroon and on bark export. The result was a spate of uncontrolled bark exploitation, particularly by young men, which focused on the major remaining source of *Prunus africana* bark in the forests of Mt. Cameroon. Several explanations are given for the over-exploitation of *Prunus africana* wildlings in Cameroon. According to [70], the top down approaches to command and control policies were ineffective due to their failure to consider perception of target groups and actors in *Prunus africana* value chain. This was further exacerbated by the failure in sustainability safeguards that had been formulated to distinguish between the legal and illegally harvested bark [71]. The failure of traceability instruments is symptomatic of inefficiencies in the enforcement command chain [15]. It is also illustrative of institutional failures in the commercialisation of medicinal plants [15, 71].

According to [15], conflict between the formal and customary institutions, inconsistent non-timber policies and legal frameworks, market structure that favours the elite investors, as well as the contestation about legitimacy to access, use and control, multiplicity of actors and flawed system of permit issuing were responsible for the degradation of *Prunus* wildlings. The foregoing reflects the role of value chain, ineffectiveness of command-control governance approaches and institutional failures on sustainability outcomes in the commercialisation of medicinal plant resources. Insufficient enforcement capacity, pervasive free rider incentives, institutional weaknesses and vested interests [72], seem to be the underlying risks that underpin such failures.

The profit motive and associated power politics in the integration of lucrative medicinal flora into global supply chain is exemplified by resistance and failure to include cultivated bark into the value chain. This was in spite of evidence that the bark from cultivated plantations had great potential for enhancing equity in the distribution of benefits to the community, as well as ensuring the sustainable exploitation of *Prunus africana* plant resources [15]. In the forest sector, vested interests are motivated by necessity for capital accumulation, as well as conflict of interest among decision, policy makers, and compliance and enforcement agencies, with the restrictive and complex permitting processes being some of the instruments used to favour elite capture of the market share [72]. Implicitly, differentials in power and knowledge relations could be a driver of vulnerability to degradation in the integration of indigenous plant genetic resources into the global value chain.

The ecological degradation risks in the exploitation of endemic medicinal plants, such as *Prunus africana* is exacerbated by climate change, pests and diseases. Such drivers could negatively influence the ecological distribution of *Prunus africana* by 2050 [73]. For example, between 1997 and 2003, 21% of the *Prunus Africana* at Ischeno, Kakamega forest, died from bark harvesting, with 9–50 % of the trees experiencing canopy dieback from other causes other than debarking [14]. Given that the genetic and chemotypic variation of *Prunus africana* reflects ancient dispersal routes and evolution in isolated vulnerable montane and rare forest ecosystems in Africa [73], the destructive harvesting practices are expected to affect the reproductive future and genetic diversity of exploited populations [74]. In the next section we explore some of the successful innovations in the agricultural value chain and identify opportunities that can support the sustainable integration of endemic medicinal flora into the global value chain.

## 5.2. Opportunities for sustainable integration of medicinal plants into global value chain

In the global medicinal plant value chain, certification and safety requirements are critical. This limits the power and influence of disorganised sellers/collectors/producers and actual participation of producer organizations in partnerships. Though partnerships are associated with some constraints, they have the potential to shorten the supply chain, improve quality and earning of premiums by farmers, as well as trigger the development of human capital associated with development of certification schemes [75]. The role of organisations in market access for plant derived medicines is thus critical [52]. For example, intersectoral partnerships can improve the position of small scale producers' organisations and stimulate adoption of certification standards that increase their visibility, market access and realisation of premium prices. In the long run, value chain partnerships increase the potential for improved environmental management [75].

Coordinating research effort, marketing and policy issue also require linkage of value chain actors at local, regional, national and international levels [70]. For example, under the sustainable livelihoods framework, the ability of MAP farmers in some parts of China to participate in global trade has been enhanced. This is seen through the formation of internal and external trade networks, and increased linkages between farmers and buyer alliances [63]. Integrated value chain (IVC) approaches, thus have the potential to solve coordination constraints, reduce vulnerability to exploitation for individual chain participants, provide a means to pricing intervention by policy makers and governments, strengthen collaboration, drive market reforms, address regulatory constraints, as well as create strong backward and forward linkages [76].

IVCs provide opportunity for forward contracting. In turn, it greatly reduces the motivation for adulteration while inducing price stability [77]. By addressing market access barriers, IVCs positively impact on efficiency, empowers and motivates primary producers to sustainably manage their resources, reinvest the higher profit margins and innovate with potential for positive impact on the eradication of rural poverty [78]. The contribution of IVCs in poverty reduction and economic growth is particularly significant for communities whose education levels are low and therefore have to depend on IK for their livelihoods [13].

Quality and safety, traceability, certification, reliability of supply, as well as, consumer tastes and preferences are critical drivers in purchasing decisions by consumers and MAP value chain [79]. The success of validated supply chain by medicinal cannabis growers in the Netherlands in which Good Agricultural practices (GAPs) are adopted to ensure traceability and guarantee human safety and efficacy of the products through a documentation process that can be monitored by internal and external auditors [59], provides an opportunity for arresting illegal harvesting and biopiracy in medicinal plant value chains. Further it provides the baseline for advancing the adoption of fair trade principles in the medicinal value chain. Fair trade principles have been used successfully in agricultural value chains e.g. the smallholder farmer tea production, to advocate for premium prices, improve product quality and promote environmental sustainability [75].

Innovative domestication of the Nagoya convention on ABS offers a window of opportunity in reducing the risk of biodiversity loss and conflicts in CPRs. The Biodiversity Economy Strategy (BES), Republic of South Africa, provides an innovative pathway that can resolve PRs conflicts, hence the sustainable integration of medicinal plants into local and global value chains. The biodiversity stewardship approach under BES, encourages voluntary agreements that support the conservation and sustainable use of biodiversity. Under the biodiversity stewardship approach, conservation authorities guide and encourage private and communal land owners to protect and manage land in biodiversity priority areas [13]. The approach, a form of Private Public Partnership (PPP), further recognises land owners as custodians of biodiversity on their land. The participatory inventory, protection and conservation of ecologically viable areas operationalises the protected Areas Act [80].

## 6. Towards a conceptual framework in the sustainable integration of medicinal plants into the global value chain

Theoretically, medicinal plants are non-excludable CPRs. The non-excludability nature of a CPR increases the tendency to free ride or gain benefits without contributing to the costs of maintaining and regulating the resource among potential beneficiaries. This increases their vulnerability to overuse or destruction [32], especially when pervasive incentives are presented by the actors in the value chain. Regulating access to CPR and enforcing rules formulated to govern its use is thus critical. However, many national agencies that govern CPR lack sufficient resources to enforce entry rules, a situation which by default change de jure state resources to de facto open resources [34]. Change of de jure state resources to de facto open resources is recipe for conflict among competing rule systems with negative impacts on resources [38], particularly in situations where external regulatory agencies and resource users create and enforce competing rules and regulations on the same resource.

Overexploitation of medicinal plant resources, such as *Prunus africana* can be explained by Micro-social theory [81] on interdependent collective action. Since bioprospecting licensees require a critical mass of individual suppliers to reduce cost of production and maximise profits, a system that by default undermines legal, regulatory and compliance frameworks is deliberately promoted by concentrating organising effort on individuals whose potential contributions are the largest. The micro social theory on interdependent collective action can thus be contextualised in explaining how free rider behaviour is incentivised and the resulting degradation risks under evolving open resource access governance systems that emerge to replace CPR governance systems in the bioprospection and commercialisation of medicinal floral. Given that open access natural resource governance systems are characterised by uncertainty in the value chain, free riding appropriation of medicinal flora, minimises risks for competing entrepreneurs but increase ecological degradation risks.

Protecting a CPR from overuse requires users or external authorities to create rules that regulate its use. Devising such rules requires joint effort of a large proportion of resource users or local collective action, a costly affair that requires that the users overcome collective action dilemmas [40]. Under formal institutional arrangements, such costs are prohibitive and unenforceable, especially there is lack of commitment and legitimacy. In such scenarios, self-organised collective action arrangements are preferable as they can produce operational rules that closely match the physical and economic conditions of a particular site [38]. Under the latter, the cost of regulation are largely borne by the same beneficiaries and institutional arrangements that internalises the costs of monitoring and exclusion [39]. Such efficacy justifies the use of IK and local collective action in lowering the costs of enforcement and pursuit of sustainability objectives.

Loss of medicinal fauna is a slow onset disaster whose impacts may not be reversed in the short term planning horizon. For example, though the donor support initiatives between 1993 and 1996 succeeded in halting the illegal harvest of *Prunus africana* on Mt. Cameroon, they were not enough to allow wild population to recover from decades of destructive harvesting [15]. Further the inclusion of *Prunus africana* in Appendix II of CITES (Convention on International Trade on Endangered species), had little success as the export ban was largely subverted with adverse ramifications on population from other countries such as, Madagascar, Kenya, Congo, Uganda and South Africa.

The less understood relationship and indistinctiveness between genetic and biological resources, ownership and traditional knowledge, as well as, patent regime systems are drivers of the divergence among majority of policy makers in conceptualization of bioprospection, where majority of the actors tend to base their decision making solely on de jure instruments. This is recipe for emergence of conflict between de facto and de jure governance system. The resulting legal dilemmas and inherent conflict creates a state of uncertainty among local level institutions [11].

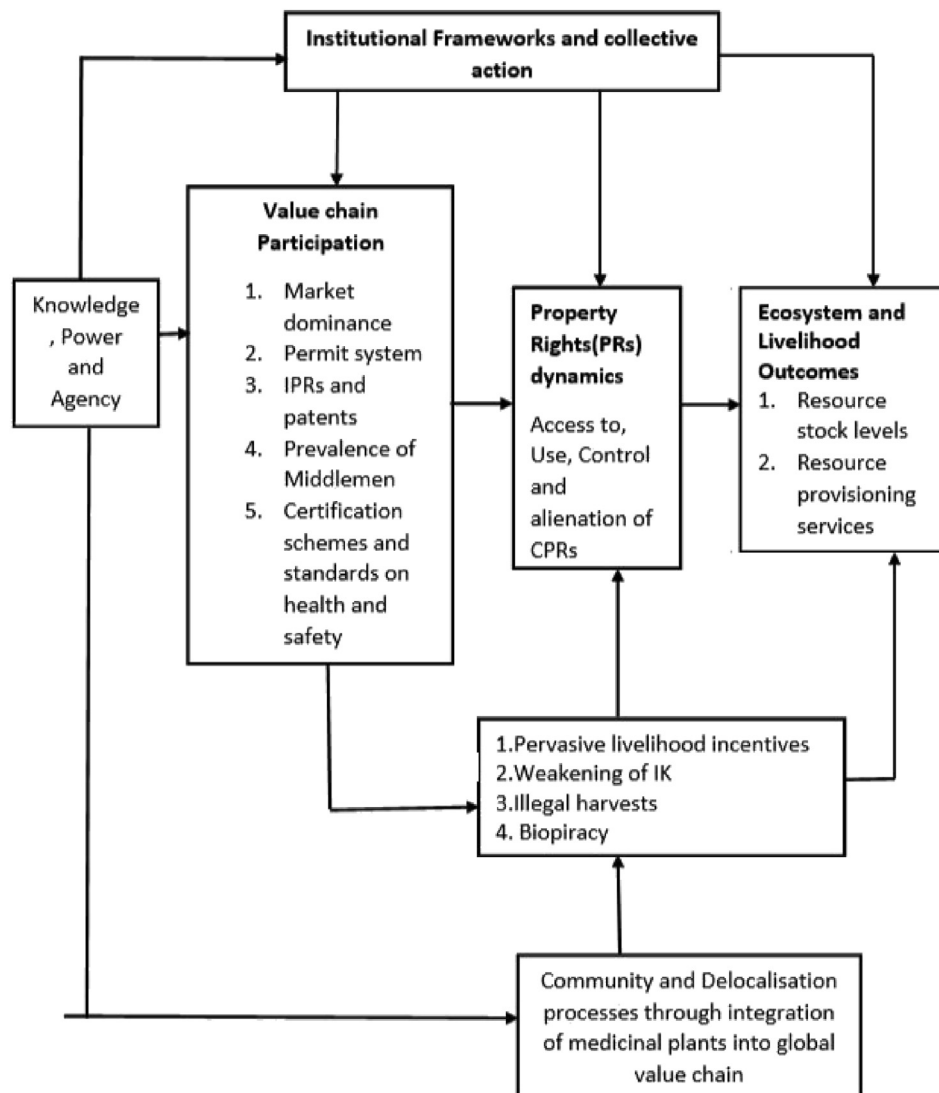


We argue that legal dilemmas, and state of uncertainty disincentivises local collective action. This is exploited by commercially oriented bio-prospectors to provide pervasive incentives that negatively impact the conservation of medicinal plants.

Since local people are the source of information for revealing the potentials of medicinal species, their distribution and local use, their participation in any intervention is critical [64]. IK is generally understood as being the result of creation and innovation by the community as a collective originator [68]. Hence, any transformation agenda for the sustainable integration of medicinal plant genetic resources into global value chains, should seek to integrate IK, property rights, power, knowledge and agency as analytical lenses in policy engagement and programming that targets sustainable utilisation at local level and integration into global value chain. We suggest a conceptual framework (Figure 3), that can be utilised in assessing ecological impacts from medicinal plant value chains. The framework may be used in the development of responsive policies on CPRs, bioprospection, conservation and sustainable utilisation of endemic medicinal flora.

### 7. Conclusions and policy implications

In this paper, we examined the interaction of power, knowledge and subjectivity on the one hand and the concept of property rights and collective action as institutional frameworks that influence ecological outcomes in medicinal plant value chains. The interactions were contextualised through a critical analysis and reference to policy failures associated with commercialisation of *Prunus africana*. We posited that value chains are critical to sustainable exploitation of medicinal plant resources. Environmental vulnerability was thus conceptualised as a cognitive attribute associated with actions and related conflict between PR systems and noncompliance outcomes arising from delocalisation processes in bioprospection initiatives. We adopted coupled H-E systems and political ecology lens to hypothesize the influence of value chain actors in degradation of endemic medicinal plant resources. Key among this is associated with lack of adequate information about consequences of human actions on the environment in coupled social-ecological interactions [3], most of the which are indirectly manifested. For example *P. Africana* appear to require disturbance of the environment for its regeneration. This increases its vulnerability to extinction and/or loss of



**Figure 3.** Conceptual framework on integration of medicinal plants into Global value Chain and ecological outcomes (Authors', 2018) Power and knowledge differentials can be conceptualized in terms of value chain participation and are sanctioned by steering mechanisms on property rights with far reaching impact on collective incentive system, biopiracy and ultimately ecosystem and livelihood outcomes such over harvesting of medicinal plant resources.

genetic diversity, presenting a formidable challenge to its conservation [14]. The analogy on high international demand as driver for increased vulnerability to overexploitation and/or extinction, breeding and governance challenges, could thus be extended to other endemic medicinal species such as *Ledebouria hypoxidoides*, *warburgia salutaris*, *Brackenridgea Zanguebarica* and *siphonochillus aethiopicus*. This has implications for their exploitation, sustainability and conservation.

We have identified significant linkages between medicinal value chains, power, knowledge, agency, property rights and ecological degradation risks in the global supply and demand of medicinal plants. Though delocalisation of community based resource management systems, such as medicinal plants offer opportunities for income earning and employment, they are biased in favour of dominant value chain actors who leverage on IPR governance systems to advance their strategic interests. Since commercialisation of medicinal plants undermine locally established values and norms that regulate access to and control of CPRs, it promotes pervasive incentives that increase vulnerability to over-exploitation and extinction of medicinal plant species. Further, in most judicial precedents, IK are considered inferior to IPR, moreso where the legal and policy frameworks are weak. IPRs, a common feature of biotechnological innovations in the isolation, processing and patenting of active ingredients from medicinal plants thus portend reaching implications on CPRs [67].

As a risk management strategy, actors in the global medicinal plant value chain offer pervasive livelihood incentives through middlemen increasing the risk of overexploitation and environmental vulnerability to degradation. Increasing demand for medicinal flora, as well as legal dilemmas, agrotechnological risks and governance challenges, are thus the main drivers for overexploitation and/or extinction of medicinal flora. We conclude that sustainable exploitation and integration of endemic medicinal plants into the global value chain require multi-pronged strategies, such as innovative domestication of the Nagoya convention on access and benefit sharing in reducing the risk of biodiversity loss and conflicts in CPRs, documentation and validation of IK. The strategies should be anchored on reflective models that recognise and integrate feedback loops, complementarity and synergy around indigenous property rights, collective action, knowledge, power relations and agency.

## Declarations

### Author contribution statement

Volenzo Tom: Conceived and designed the experiments; Wrote the paper.

John Odiyo: Conceived and designed the experiments.

### Funding statement

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

### Competing interest statement

The authors declare no conflict of interest.

### Additional information

No additional information is available for this paper.

## Acknowledgements

The research is part of Post-Doctoral Research Fellowship programme, University of Venda and courtesy of the Department for Higher Education (DHET), Republic of South Africa.

## References

- [1] MEA, "Ecosystems and Human Well-Being: A Framework for Assessment," Island Press, Washington, Covelo and London, 2003.
- [2] H.R. Ojha, R. Ford, R.J. Keenan, D. Race, "Delocalizing Communities :: changing forms of community engagement in natural resources governance," *World Dev.* 87 (2016) 274–290.
- [3] C. Folke, S.R. Carpenter, B. Walker, M. Scheffer, T. Chapin, J. Rockström, "Resilience Thinking : integrating resilience, Adaptability and," *Ecol. Soc.* 15 (no. 4) (2010).
- [4] S.H. Eriksen, A.J. Nightingale, H. Eakin, "Reframing adaptation: the political nature of climate change adaptation," *Glob. Environ. Chang. Times* 35 (2015) (2015) 523–533.
- [5] FAO, "Trade in Medicinal Plants," Rome, Italy, Background Papers Prepared for Workshop on Medicinal Plants, 2004, pp. 22–26. July 2004 Bangalore, India.
- [6] European Union EU, Directive 2001/83/EC of the European parliament and of the council of 6 november 2001 on the community code relating to medicinal products for human use as amended by directive 2002/98/EC of the European parliament and of the council of 27 January, no. Eur. Union Polit. 2004 (November 2001) 67–128.
- [7] World Health Organization, "WHO Guidelines on Good Agricultural and Collection Practices (GACP) for Medicinal Plants," 2003. Geneva, Switzerland.
- [8] R.A. Street, G. Prinsloo, "Commercially important medicinal plants of South Africa: a review," *J. Chem.* (2013) 2013.
- [9] R. Singh, "Medicinal plants : a review," *J. Plant Sci.* 3 (no. 1) (2015) 50–55.
- [10] UN comtrade, "Export-Import Value of Products Reported in Code HS1211," Trade Statistics Database Reported in Code H1211. Department of Economics and Social Affairs, Statistics Division [Online]. Available: <http://comtrade.un.org/data/>, 2018 [Accessed: 24-Oct-2018].
- [11] K.P. Oli, "Access and benefit sharing from biological resources and associated traditional knowledge in the HKH region -protecting community interests," *Int. J. Biodivers. Conserv.* 1 (5) (2009) 105–118.
- [12] W.V. Reid, et al., "Biodiversity Prospecting: Using Genetic Resources for Sustainable Development," World Resources Institute, Washington, Washington D.C, 1993.
- [13] DEAT Department of Environmental Affairs and Tourism, "South Africa's National Biodiversity Strategy and Action Plan," Pretoria, 2005.
- [14] P.J. Fashing, "Mortality trends in the African cherry (*Prunus africana*) and the implications for colobus monkeys (*Colobus guereza*) in Kakamega Forest, Kenya," *Biol. Conserv.* 120 (4) (2004) 449–459.
- [15] A. Cunningham, V.F. Anoncho, T. Sunderland, "Power, policy and the *Prunus africana* bark trade, 1972-2015," *J. Ethnopharmacol.* 178 (2016) 323–333.
- [16] B.G. Ndawonde, A.M. Zobolo, E.T. Dlamini, S.J. Siebert, "A survey of plants sold by traders at Zululand muthi markets, with a view to selecting popular plant species for propagation in communal gardens," *Afr. J. Range Forage Sci.* 24 (2) (2007) 103–107.
- [17] A.T. Peterson, D.M. Watson, "Problems with areal definitions of endemism : the effects of spatial scaling," *Conserv. Biogeography* 4 (1998) (1998) 189–194.
- [18] J. Liu, "Integration across a metacoupled world," *Ecol. Soc.* 22 (4) (2017).
- [19] E.G.B. Xu, K.M.Y. Leung, B. Morton, J.H.W. Lee, "An integrated environmental risk assessment and management framework for enhancing the sustainability of marine protected areas :: the Cape d ' Aguilar Marine Reserve case study in Hong Kong," *Sci. Total Environ.* 505 (2015) 269–281.
- [20] H. Xiong, J. Millington, W. Xu, "Trade in the telecoupling framework :: evidence from the metals industry," *Ecol. Soc.* 23 (1) (2018).
- [21] V. Hull, C.J. Rivera, C. Wong, "A synthesis of opportunities for applying the telecoupling framework to marine protected areas," *Sustainability* 11 (4450) (2019) 1–18.
- [22] J. Liu, W. Yang, "Integrated assessments of payments for ecosystem services programs," *Proc. Natl. Acad. Sci. Unit. States Am.* 110 (41) (2013) 16297–16298.
- [23] R.P. Bixler, J. Dell'Angello, O. Mfune, H. Roba, "The political ecology of participatory conservation : institutions and discourse," *J. Polit. Ecol.* 22 (2015) (2015) 165–182.
- [24] M.J. Simsik, "The political ecology of biodiversity conservation on the Malagasy Highlands," *Geojournal* 58 (4) (2002) 233–242.
- [25] A. Nightingale, "Nature-society and development: social, cultural and ecological change in Nepal," *Geoforum* 34 (4) (2003) 525–540.
- [26] E.M. Biggs, et al., "Sustainable development and the water – energy – food nexus :: a perspective on livelihoods," *Environ. Sci. Pol.* 54 (2015) (2015) 389–397.
- [27] M. Foucault, Governmentality, in: *The Foucault Effects. Studies in Governmentality*, Harvester Wheatsheaf, Hempstead, London, 1991.
- [28] A.J. Nightingale, "Beyond design principles: subjectivity, emotion, and the (Ir) rational commons," *Soc. Nat. Resour.* 24 (2) (2011) 119–132.
- [29] M. Foucault, *Discipline and Punish*, second ed., Vintage Books, New York, 1995.
- [30] H. Arendt, *Between Past and Future: Eight Exercises in Political Thought*, Penguin Books, Newyork, 1993.
- [31] A.J. Nightingale, H.R. Ojha, "Rethinking power and authority: symbolic violence and subjectivity in Nepal's terai forests," *Dev. Change* 44 (1) (2013) 29–51.
- [32] J.C. Ribot, "Vulnerability Does Not Just Fall from the Sky," in *Social Dimensions of Change in Awariming World*, 2010.
- [33] H. Eakin, K. Appendini, "Livelihood change, farming, and managing flood Risk in Lerma Valley, Mexico," *Agric. Hum. Val.* 25 (2008) 555–566.
- [34] E. Ostrom, "An Institutional Approach to the Study of Self-Organization and Self-Governance in CPR Situations," in *Governing the Commons :: the Evolution of Institutions for Collective Action*, Cambridge University Press, Cambridge, 1990, pp. 29–57.

- [35] D.C. North, "Institutions, institutional change, and economic performance," *J. Econ. Perspect.* 5 (1) (1991) 97–112.
- [36] G. Winter, "Perspectives, Sociology and the Law," in *Multilevel Governance of Global Environmental Change*, in: G. Winter (Ed.), Cambridge University Press, Cambridge, 2006, pp. 77–78.
- [37] D.W. Bromley, *Environment and Economy: Property Rights and Public Policy*, Basil Blackwell Ltd, Blackwell, 1991.
- [38] E. Schlager, E. Ostrom, "Property-Rights regimes and natural Resources : a conceptual analysis," *Land Econ.* 68 (3) (1992) 249–262.
- [39] F. Berkes, "Marine Inshore Fishery Management in Turkey," in *Common Property Resource Management*, 1986, pp. 63–83.
- [40] N. Dolsak, E. Ostrom, "Challenges and Adaptation; Politics, Science and the Environment," in *the Commons in the Millenium*, Cambridge, MIT Press, 2003.
- [41] R.H. Coase, "The problem of social cost," *Law Econ.* 3 (1960) 1–44.
- [42] M.A. Knox, R. Meinzen-dick, P. Hazell, "Technologies for Natural Resource Management : CGIAR System-wide Program on Property Rights and Collective Action," Baltimore and London, 1998. Working Paper No.1.
- [43] K. Brown, "Three challenges for a real people-centered conservation," *Global Ecol. Biogeogr.* 12 (2) (2003) 89–92.
- [44] P. Blaikie, "Is small really Beautiful ? Community-based natural resource management in Malawi and Botswana," *World Dev.* 34 (11) (2006) 1942–1957.
- [45] F. Berkes, "Rethinking community-based conservation," *Conserv. Biol.* 18 (3) (2004) 621–630.
- [46] S.H. Gordon, "The economic theory of a common-property resource: the fishery," *J. Polit. Econ.* 62 (2) (1954) 124–142. April, 1954.
- [47] A. Scott, "The fishery: the objectives of sole ownership," *J. Polit. Econ.* 63 (1955) 116–124.
- [48] J.C. Cordell, M.A. Mckean, "Common property resource management," in *sea tenure in Bahia, Brazil* 118 (5) (1987) 85–114.
- [49] A. Agrawal, C.C. Gibson, "Enchantment and Disenchantment : the role of community in natural resource conservation," *World Dev.* 27 (4) (1999) 629–649.
- [50] R. Constanza, et al., "Managing our environmental portfolio," *Bioscience* 50 (6) (2000) 501–508.
- [51] E. Ostrom, R. Gardner, J. Walker, *Rules, Games, and Common-Pool Resources*. Michigan, University of Michigan Press, 1994.
- [52] H. Mebrahtu, A. Zemedu, G. Mirutse, "Review of Value chain analysis of medicinal plants and the associated challenges," *Med. Plants Stud.* 4 (3) (2016) 45–55.
- [53] S. Parwez, "A conceptual model for integration of Indian food supply chains," *Global Bus. Rev.* 17 (4) (2016) 834–850.
- [54] A. Booker, D. Johnston, M. Heinrich, "Value chains of herbal medicines - research needs and key challenges in the context of ethnopharmacology," *J. Ethnopharmacol.* 140 (3) (2012) 624–633.
- [55] R. Kaplinsky, "Globalisation and Unequalisation : what can Be learned from value chain Analysis ? Globalisation and unequalisation," *J. Dev. Stud.* 37 (2) (2000).
- [56] E. Giuliani, C. Pietrobelli, R. Rabellotti, "Upgrading in global value chains: lessons from Latin American clusters," *World Dev.* 33 (4) (2005) 549–573.
- [57] C.P. Kala, P.P. Dhyani, B.S. Sajwan, "Developing the medicinal plants sector in northern India: challenges and opportunities," *J. Ethnobiol. Ethnomed.* 2 (32) (2006) 15.
- [58] KIT, *Cultivating a Healthy Enterprise*, Amsterdam 350, 2003.
- [59] A. Lubbe, R. Verpoorte, "Cultivation of medicinal and aromatic plants for specialty industrial materials," *Ind. Crop. Prod.* 34 (1) (2011) 785–801.
- [60] P.C. Phondani, I.D. Bhatt, V.S. Negi, B.P. Kothiyari, A. Bhatt, R.K. Maikhuri, "Promoting medicinal plants cultivation as a tool for biodiversity conservation and livelihood enhancement in Indian Himalaya," *J. Asia-Pacific Biodivers.* 9 (1) (2016) 39–46.
- [61] UN Convention on Biological Diversity Secretariat, "Nagoya protocol on access to genetic resources and the fair and equitable sharing of benefits arising from their utilisation," Montreal, Canada, 2011.
- [62] E.J. Kayombo, R. Mahunnah, F. Uiso, "Prospects and challenges of medicinal plants conservation and traditional medicine in Tanzania," *Anthropology* 1 (3) (2013).
- [63] P.H. Canter, H. Thomas, E. Ernst, "Bringing medicinal plants into cultivation: opportunities and challenges for biotechnology," *Trends Biotechnol.* 23 (4) (2005) 180–185.
- [64] S. Padulosi, D. Leaman, P. Quek, "Challenges and opportunities in enhancing the conservation and use of medicinal and aromatic plants," *J. Herbs, Spices, Med. Plants* 9 (4) (2002) 243–267.
- [65] A. Barirega, J.R.S. Tabuti, P. Van Damme, J.G. Agea, V. Muwanika, "Potential for commercialization and value chain improvement of wild food and medicinal plants for livelihood enhancement in Uganda," *Curr. Res. J. Biol. Sci.* 4 (2) (2012) 108–116.
- [66] G. Alam, J. Belt, "Developing a Medicinal Plant Value Chain : Lessons from an Initiative to Cultivate Kutki ( Picrorhiza Kurrooa ) in Northern India," WPS C5, Amsterdam, 2009.
- [67] WIPO, *The Enforcement of Intellectual Property Rights: Acase Book*, Third Edit, WIPO Publications, Geneva, Switzzeland, 2012.
- [68] A. Laura, J.D. Foster, "Inventing Hoodia: Vulnerabilities and Epistemic Citizenship in South Africa," 2011.
- [69] S. Kadidal, "United States patent prior art rules and the neem controversy: a case of subject-matter imperialism?," *Biodivers. Conserv.* 7 (1) (1998) 27–39.
- [70] J. Mayers, S. Bass, *Policy that Works for Forests and People. Real Prospects for Governance and Livelihoods* 136, Earthscan, London, 2004.
- [71] V.J. Ingram, "Win-wins in NTFP Market Chains ? How Governance Impacts the Sustainability of Livelihoods Based on Congo Basin forest Products," Amsterdam, 2014.
- [72] V. Ingram, A. Awono, J. Schure, N. Ndam, *Guidance for a National Prunus Africana Management Plan Cameroon*, No. June, Centre for International Forestry Research(CFOR), Yaounde, Cameroon, 2009.
- [73] B. Vinceti, et al., "Conservation priorities for prunus africana defined with the aid of spatial analysis of genetic data and climatic variables," *PloS One* 8 (3) (2013).
- [74] N. Farwig, C. Braun, K. Böhning-Gaese, "Human disturbance reduces genetic diversity of an endangered tropical tree, *Prunus africana* (Rosaceae)," *Conserv. Genet.* 9 (2) (2008) 317–326.
- [75] V. Bitzer, P. Glasbergen, B. Arts, "Exploring the potential of intersectoral partnerships to improve the position of farmers in global agrifood chains: findings from the coffee sector in Peru," *Agric. Hum. Val.* 30 (1) (2013) 5–20.
- [76] A.C. Hamilton, "Medicinal plants, conservation and livelihoods ALAN," *Biodivers. Conserv.* 13 (2004) 1477–1517.
- [77] A. Booker, D. Frommenwiler, D. Johnston, C. Umealajekwu, E. Reich, M. Heinrich, "Chemical variability along the value chains of turmeric (*Curcuma longa*): a comparison of nuclear magnetic resonance spectroscopy and high performance thin layer chromatography," *J. Ethnopharmacol.* 152 (2) (2014) 292–301.
- [78] A. Sahahidullah, C.E. Haque, "Linking medicinal plant production with livelihood enhancement in Bangladesh: implications of a vertically integrated value chain," *J. Transdiscipl. Environ. Stud.* 9 (2) (2010) 1–18.
- [79] DAFF Department of Agriculture and Forestry, "A Profile of the South African Rooibos Market Value Chain," Pretoria, 2016.
- [80] Republic of South Africa, *National Environmental Management: Protected Areas Act*, 2003, 2004 vol. 464, no. 181. South Africa.
- [81] M. Gerald, E.O. Pamella, P. Ralph, "Social networks and collective action: a theory of the critical mass. III," *Am. J. Sociol.* 94 (4) (1988) 503–534.