 doi:10.20944/preprints201811.0053.v1

Conceptualization

Integrating endemic medicinal plants into the global value chains: The ecological degradation challenges and Opportunities

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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 wild medicinal plant resources are exacerbated by a myriad of agrotechnological risks and challenges that highly constrain their domestication. Successful exploitation and commercialization 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 in turn 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.

Keywords: Bio-prospecting; Biopiracy; Collective Action; Common Property Resources; Ecosystem sustainability; Natural Resource Management, Institutions, Property Rights, Value chain.

1.0 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 or cultural services, 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 observation is critical given that 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 needs rethinking and reframing of policy and practice, engaging multiple knowledges, as well as, questioning

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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 Union directive 2001/83/EC (6), requires provision of extensive documentation of physicochemical, biological and microbiological, as well as, 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 the 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. The global trade value of medicinal and aromatic plants (MAPs) is in the range of US$800 million per year. The demand is projected to grow at a rate of 15-25%, with an estimated value of US$ 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) provides some statistics [11] on the value and trends in the global value chain of Medicinal and aromatic plants (MAPs)

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

Country/Year		Exports (Tons)	Value(USSD)	Import (Tons)	Value(USSD
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

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	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, Only figures reported in Code HS 1211. NA, Not available

Commercialisation of medicinal plants normally follows bio-prospecting and patenting trajectories [12]. Bioprospecting is the exploration of biological material for commercially valuable genetic and biochemical properties [13]. Bioprospecting includes all studies to determine the chemical profile and composition of medicinal plants [8]. This has prompted the government of South Africa to identify and place medicinal plants as part of the newly launched biodiversity economy aimed at empowering local communities that grow and sell these plants for medicinal purposes [14]).

Bio-prospecting is to a great extent anchored on indigenous knowledge systems hence institutions of collective action [12]. 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 reveal that bioprospecting and subsequent commercialisation of medicinal plants has had mixed outcomes in Africa and other parts of the world [15,16]. For example, the increased vulnerability to extinction of a number of medicinal flora, *such as, Hypoxis hemerocallidea* is attributed to high demand, destructive harvesting practices and inherent slow growth of the endemic species [17]. The slow growth is an underlying risk in ecological degradation.

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. As 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 the ecological risks associated with integration of endemic medicinal plant species into the global value chain.

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 [16]. By examining the concept of property rights and collective action, and the closely related triumvirate of knowledge, power and subjectivity. We further attempt at closing existing gaps on the role of institutional and environmental economics [16], in the exploitation and integration of medicinal 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 bioprospection 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 value chains.

2.0 The triumvirate of knowledge, power and subjectivity in Natural Resource Management

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 [18]. 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 [19]. 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 [20]. 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 [18].

Subjects are cognitive attributes defined by positions of individuals in a social system. 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 localites and larger scale institutions [18].

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 [20]. Power can thus be enacted either as a tool for domination over or empowerment [20,21], with consequences on social differentiation [22]. The enactment of power may have negative, as well as, positive outcomes on livelihoods [4].

The political domain of power broadly refers to processes through which individuals and collectives cooperate and collude in order to govern their affairs[23]. Authority captures competition for influence and ability to exert agendas by one individual or n institution over the other[24]. 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 [25], or between different social groups. Biased decision making may in turn result in lost opportunities and mis-characterisation of the underlying risks [26]. The foregoing is critical in frameworks that attempt to link value chains and environmental vulnerability.

The centrality of compliance and conflict is critical in the analysis of risks and opportunities from increasing markets for natural products, as well as, the integration of 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.

Fig 1: key interactions framing adaptation planning ([4])

3.0 Institutional frameworks, Property Rights and sustainability in Natural Resource Management

Institutions are the rules, values and practices that guide formal and informal organisations[27]. 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, profitability and feasibility of engaging in an economic activity [28].

Various collection of institutions come together to form 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 [29]. 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' claim to a benefit stream and claim[30]. 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, dejure 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 [31]. A conglomeration of dejure and defacto property rights, however, may be in existence to compliment, overlap or conflict with one another. In many situations, dejure authorised users or claimant rights and defacto proprietor arrangements which are understood, followed and perceived as legitimate within the local community emerge [32]. Essentially dejure authorised users could be defacto claimants over a common pool resource.

The effect of resource characteristics, characteristics of resource users, economic, political and legal ,as well as, technological factors on CPR are given by [33]. Such factors are 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 [34]. 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 [35].

Natural resource management is vulnerable to institutional failures [36].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 fueled through competition, collusion and conflict during policy discourses which cement rationalities and promote particular regimes of governance [4]. In this way natural resource management has been hijacked to legitimise strategic interests of development agencies, state organisations and dominant market players [37]. Accordingly, community actions are increasingly being shaped by outside forces rather than locally initiated collective action [38]. This view is extended in the next section through examination of design challenges and some policy reform 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 [39]. Accordingly there is need to analyse the role of knowledge, power and agency and how they are mediated for sustainable outcomes under complex interrelations involving property rights, collective action and natural resource management. This especially critical in natural resource ownership discourses.

The various forms of natural resource ownership are Open access resource (OPR) and CPR [27] . Under (OPR) ownership, no limit is placed on who can appropriate and no appropriator has any incentive to leave any resource unit for other appropriators to harvest [40,41]. In theory, alienation through privatization, should permit a resource to be shifted from a less productive to more productive use [40]. 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 leading to loss of genetic and biological resources [42]. 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, 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 after dejure rules were used to challenge defacto rules [40]. Since global medicinal value chains to a greater extent rely on the extensive collection of wildings, property rights, indigenous knowledge(IK) and the closely related collective action lenses are critical in the mitigation of associated ecological risks.

4.0 Community as an institution in Natural resource management

Communities have been viewed from different analytical lenses in Natural Resource Management discourses. Under 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 [43], 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.

There exists opposing scholarly views on the impact of delocalisation on natural resources management outcomes. On one hand, it is urged that delocalisation can 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 [24]. 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, including 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 [33].

In assessing environmental vulnerability, the most relevant operational level PRs are access and withdrawal rights. This has close relation to the problem of appropriation, maintaining the resource stock, uncertainty over 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 in the process reducing the marginal returns and/ or the marginal costs of appropriation[44].

Participation in the formulation and implementation of decisions concerning environmental resources is among the sustainable solutions on governance with complex environmental challenges[44]. This is a form of collective action (CA). Collective action is enhanced when PRs and the institution for its enforcement are neither challenged nor undermined[45]. Excludability [27] , is one of the conditions that creates and sustains effective collective action in the management of CPRs, such as, medicinal plants.

5.0. Challenges and potential solutions in medicinal plant value chains

Successful commercialization require a clear understanding of the demand and production systems of the plants and/or their derivative products, as well as, market information assessment or value chain analysis. A value chain includes the full range of activities that are required to bring a product from its origin, through different phases of production, to its final customer [46,47]. The activities in the value chain include research, production, transportation/ distribution, processing and trading, warehousing/ storage activities geared towards meeting consumer 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.

Value chains hold a critical role in the sustainable commercialisation and integration of medicinal plants especially the wildings. Though few value chain studies have been done on medicinal plants, available findings suggest that they are critical to sustainability, equity and safety of herbal medicines [48]. Value chains can be used to account for power and dominance relationships between different actors, such as, producers, retailers, middlemen and associated differences in income accruing to them, the characteristics of the final product, as well as, the competitive advantage of the product over similar products [49,50]. We posit that value chains are critical to sustainable exploitation of medicinal plant resources.

Medicinal plants value chain is among the highly inequitable and unregulated hence they tend to be inefficient [51,52]. In the upstream value chains, market information, capital and skills, volume, quality, and consistency of supply are major bottlenecks, especially in small scale farmers' value chains[52]. In particular, medicinal plant supply chains are extra ordinarily long and dominated by middlemen. Poor availability of market information exacerbates disincentives in medicinal value chains[51]. The domination by middlemen greatly reduces the margins to farmers and harvesters. It further increases the risk of biopiracy or the patenting and selling pharmaceutical agents derived from indigenous plant species without acknowledging or providing financial compensation for the traditional knowledge or royalties earned from the sales of the drugs to the source countries of the plants. Fig 2 gives an illustration of an ideal medicinal value chain

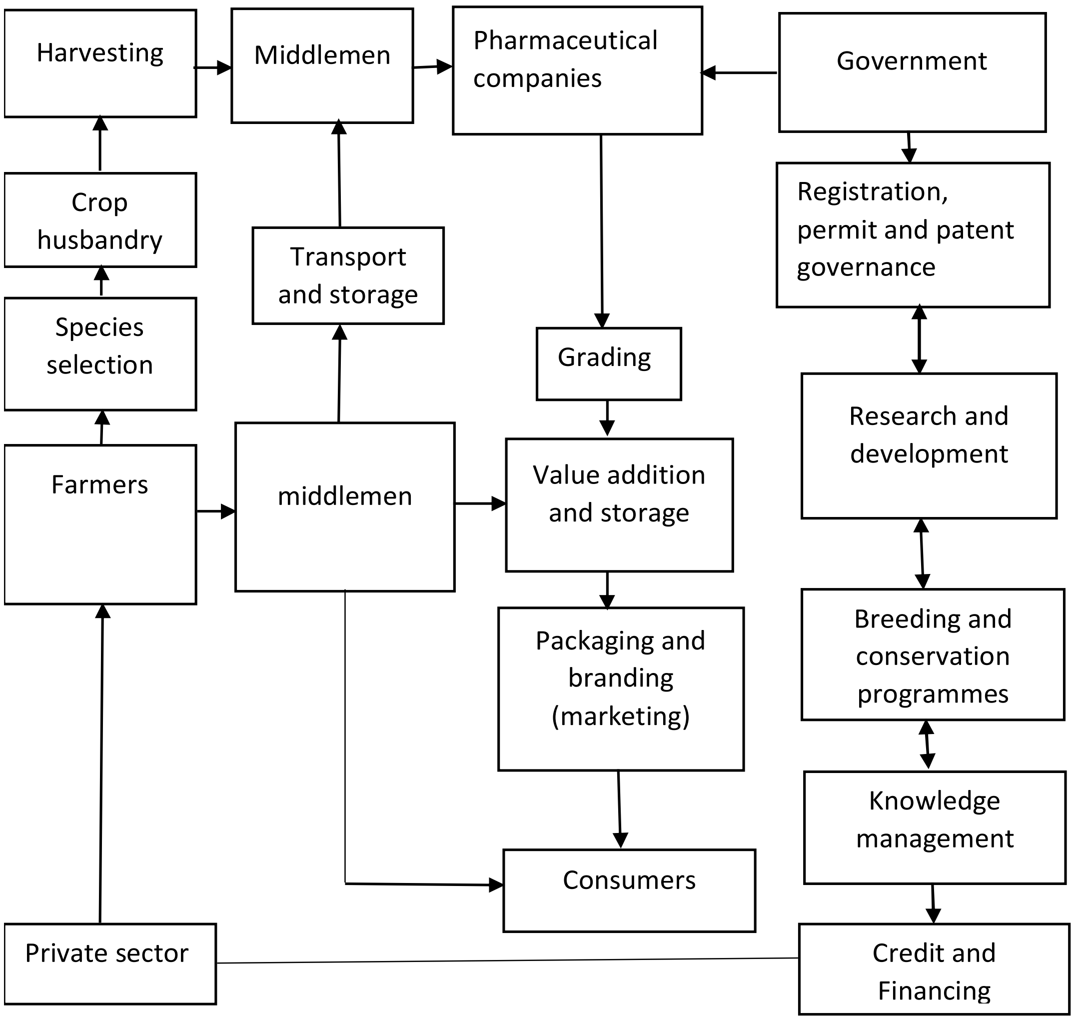

Fig 2 : Medicinal and Aromatic Plants Value chain (Adapted from Phondani *et al.*, 2016)

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 [12,13]. 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 becomes integral part to the conservation of biological diversity. However, medicinal plants are faced by continuous erosion of the IK among many other threats [51] ,as well as, biopiracy [14].

Lack of and/or inadequate governance systems on intellectual property rights in most developing countries increases the vulnerability of their genetic resources to biopiracy[46]. Under Nagoya convection on access to and benefit sharing (ABS) protocol [13], utilisation of genetic resources, research on genetic or biochemical composition of genetic resources, as well as, subsequent application and commercialization 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 [12]. Though the Nagoya protocol has the potential to strengthen collective action and claims to benefits from bioprospection of genetic resources, it does not conclusively resolve governance dilemmas on IK and CPRs.

 doi:10.20944/preprints201811.0053.v1

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[53,5]. For example, in a study in Tanzania, the indiscriminate and widespread harvesting of wild medicinal flora extended into sacred forests with many plant species becoming extinct or endangered[54]. Risks of extinction could negatively impact livelihoods, economies and health especially in communities where medicinal plants are found[14,55].

Biotechnology and domestication of MAPs can be adopted to address the threat of resource overexploitation. Molecular marker assisted selection, tissue culture and genetic transformation which alter pathways for biosynthesis of target metabolites are some of the biotechnological technologies with potential for rapid domestication of MAPs [56]. Though domestication of medicinal plants provides opportunities for overcoming misidentification, genetic and phenotypic variability, extract variability and contamination risks [56], the existence of agrotechnology challenges, such as, 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, constraints domestication pathways [51]. Domestication of 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[57]. This could be the plausible reason for preference of wildings in the medicinal value chain. Sustainable exploitation of the wild plant genetic resources is thus critical.
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 [58]. This possibly accounts for dominance of medicinal value chain by 12 countries. According to [59], 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 returns for suppliers of medicinal plant resources.

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

Country of import	Tonnes	Value(USSD)	Country of export	Tonnes	Value(USSD)
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)

The major sources of risks to commercialisation of medicinal plants through deliberate cultivation (domestication) include biopiracy, illegal collection, long gestation period to maturity, unresponsive permit /licencing systems, dispersed producers and lack of linkages among chain actors[51], as well as, poor quality planting material and uneconomic plots adopted by farmers [60,51]. Other risks include uncertainty on future market demand(on account that some medicinal plants are sources of multiple pharmaceutical active ingredients hence of high risk to any investor to commit funding to a single plant production), as well as, preferences for naturally sourced products by consumers [56]. Other bottlenecks to field cultivation include lack of detailed and accurate market information[61,51,5]. Reliance on wildings could thus be a risk management strategy in the medicinal plant value chain.

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 [62]. Accordingly, under patent law, the synthesis of biochemical compounds is not part of the indigenous medical knowledge [62,63]. 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 [62,64]. The inherent contradiction has potential to weaken IK, promote biopiracy, as well as, monopolistic tendencies with negative impact on international price for the affected plant derived products [64]. Decline in IK constraints the development of MAPs [51,5].

The pervasiveness of bio-piracy in medicinal plant value chains is illustrated by cases challenging the granting of patents on antifungal extracts from Neem tree (*Azadirachta indica*) and anti-cancer agents from turmeric *(Curcuma longa)* among others [62,64]. Since knowledge (in particular IK) is intangible, it is difficult to protect it legally by means of IPR instruments, such as, patents, copyright, or trade secret registration. On the other hand, the use of technology, including biotechnology, to develop a useful product (such as the isolation and commercialisation of active ingredients) from medicinal plant resources based on traditional knowledge stocks is generally protected under patent law and IPR systems[62]. The interplay between indigenous knowledge, biopiracy and weakness of international conventions and national legal frameworks is further illustrated by several other case studies, such as, the patenting of chemotherapeutic agent, vinblastine, from rosy periwinkle(*Catharanthus roseus*), a native of Madagascar and the drama around Hoodia (*Hoodia gordonii*), a succulent plant used for centuries by indigenous San people of South Africa.

5.1 Value chains, commercialisation and Ecological degradation risks: The case of *Prunus africana*

MAPs 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[65,57]. In particular, wild medicinal plants are an important source of livelihood for many of the poor people in developing countries [48]. In addition to meeting the requirements of medicine for an increasing human population, plant derived medicines have minimal side effect relative to synthetic medicines [51]. 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 [16]. 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 licenses for *P. africana* bark exploitation to additional fifty entrepreneurs. The award of quotas to additional entrepreneurs was not based on any forest inventories or assessments of sustainable harvest technologies[16]. 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 permitees by default transformed CPR into an open access resource.

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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 wildings in Cameron. According to [66], 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 [67]. The failure of traceability instruments is symptomatic of inefficiencies in the enforcement command chain[16]. It is also illustrative of institutional failures in the commercialisation of medicinal plants[16,67].

According to [16], 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 wildings. The foregoing reflects the role of value chain, ineffectiveness of command–control governance approaches and institutional failures on sustainability outcomes in commercialisation of medicinal plant. Insufficient enforcement capacity, pervasive free rider incentives, institutional weaknesses and vested interests[68], seem to be the underlying risks underpinning such failures.

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 [68]. 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 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 inspite 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[16].

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 [69]. 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 [15]. 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 [69], the destructive harvesting practices are expected to affect the reproductive future and genetic diversity of exploited populations [70]. 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 development of human capital associated with development of certification schemes [71]. The role of organisations in market access for plant derived medicines is critical [46]. This includes collaboration and partnership along the value chain. 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 [71].

Coordinating research effort, marketing and policy issue also require linkage of value chain actors at local, regional, national and international levels [57]. 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 [48]. 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 [47].

IVCs provide opportunity for forward contracting. In turn, it greatly reduces the motivation for adulteration while inducing price stability [72]. 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 [73]. 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 [14].

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 [74].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 [53], 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 in agricultural value chains e.g. the smallholder farmer tea production, to advocate for premium prices, improve product quality and promote environmental sustainability [71].

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 [65]. The approach, a form of Private Public Partnership(PPP), 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 [75].

The controversy between India and a USA firm (W.R.Grace & Co) on the patenting of products from *Azadirachta indica* and *Curcuma longa* is illustrative of the role documentation, biotechnology, a priori information, conflict and compliance to International conventions vis avis 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 [62]. In contrast, it won the turmeric contest on balance of evidence providing extensive documentation of traditional knowledge databases concerning the use of the plant in 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.

6.0 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 [33], 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 dejure state resources to defacto open resources [27]. Change of dejure state resources to defacto open resources is recipe for conflict among competing rule systems with negative impacts on resources[31], 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 [76] 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 emergence to replace CPR governance systems in 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 [33]. 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 [31]. 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[77]. 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 [16]. 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, in which the majority of the actors have the tendency to solely base their decision making on de jure instruments. This is a recipe for emergence of conflict between defacto and de jure governance system. The resulting legal dilemmas and inherent conflict creates a state of uncertainty among local level institutions [12]. 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 [57]. IK is generally understood as being the result of creation and innovation by the community as a collective originator [62]. Hence, any transformation agenda pursuing 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 and planning lenses. We suggest a conceptual framework(Fig. 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.

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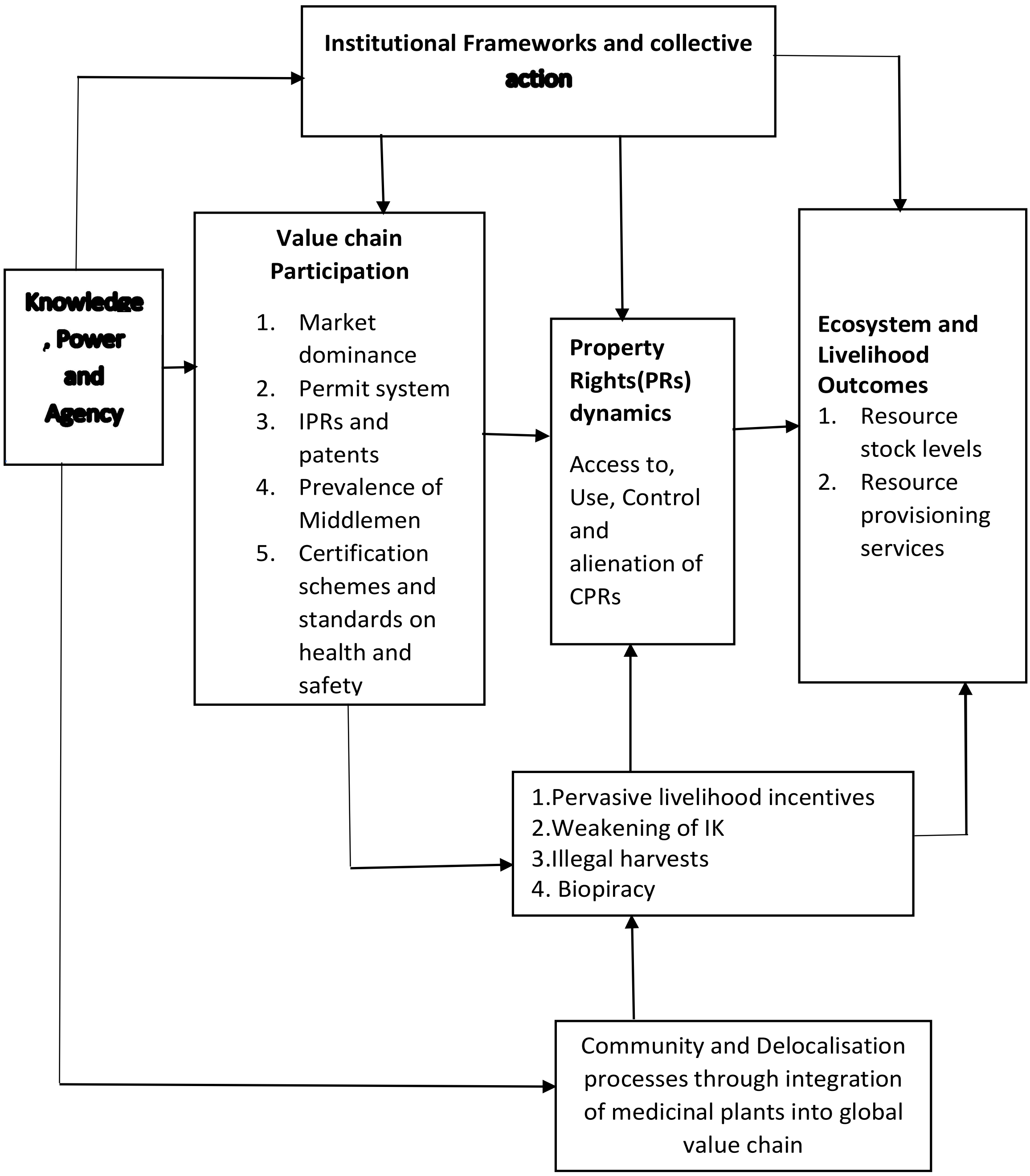

Figure 3: Conceptual framework on integration of medicinal plants into Global value Chain and ecological outcomes (Authors', 2018)

7.0 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 as critical factors 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 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 have identified significant linkages between medicinal value chains, power, knowledge, agency, property rights and ecological degradation risks. 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 actors in the value chain**.** Accordingly, commercialisation of medicinal plants undermine locally established values and norms that regulate access to and control of CPRs through creation of pervasive incentives. The pervasive livelihood incentives offered by middlemen in the value chain lead to the overexploitation of medicinal plant resources and ultimately 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 multipronged 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 that enhance complementarity and synergy around indigenous property rights, collective action, knowledge, power relations and agency**.**

Acknowledgment: 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
Declaration of Interest: The authors declare that they have no financial or personal relationships that may have inappropriately influenced them in writing this article
Author's contribution: Dr. Volenzo Tom Elijah was the originator of research idea and conceptual framework and wrote the manuscript, Prof. John Odiyo advised on the organisation, edited and revised the manuscript, Offoro contributed to refining of the conceptual framework.

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