

# Reimagining invasions; the social and cultural impacts of Prosopis on pastoralists in Southern Afar

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1 **Reimagining invasions; the social and cultural impacts of Prosopis on pastoralists in**  
2 **Southern Afar**

3 **Abstract:** Whilst the environmental impacts of biological invasions are clearly conceptualised  
4 and there is growing evidence on the economic benefits and costs, the social and cultural  
5 dimensions remain poorly understood. This paper presents the perceptions of pastoralist  
6 communities living in southern Afar in the Ethiopian lowlands on one invasive species,  
7 *Prosopis juliflora*. The socio-cultural impacts are assessed and the manner in which they  
8 interact with other drivers of vulnerability, including political marginalisation, sedentarization  
9 and conflict, are explored. The research studied 10 communities and undertook a series of  
10 semi-structured interviews and focus group discussions with pastoralists and agro-  
11 pastoralists. These results were supported by interviews with community leaders and key  
12 informants and the benefits and costs were analysed using the asset-based framework of the  
13 Sustainable Livelihoods Framework and the subject-focused approach of Wellbeing in  
14 Development. The results demonstrate that the costs of invasive species are felt across all of  
15 the livelihood capital bases (financial, natural, physical, human and social) highlighted within  
16 the framework and that the impacts of the *P. juliflora* invasion, such as reducing access  
17 through blocking roads, cross multiple assets. The concept of Wellbeing in Development  
18 provides a lens to examine neglected impacts, like conflict, community standing, political  
19 marginalisation and cultural impoverishment, and a freedom of definition and vocabulary to  
20 allow the participants to define their own epistemologies. The research highlights that  
21 impacts spread across assets, transcend objective and subjective classification but also  
22 interact with other drivers of vulnerability. Pastoralists report deepened and broadened  
23 conflict, complicated relationships with the state and increased sedentarization within

1 invaded areas. The paper demonstrates that biological invasions have complex social and  
2 cultural implications beyond the environmental and economic costs which are commonly  
3 presented. Through synthesising methodologies and tools which capture local knowledge  
4 and perceptions these implications and relationships are conceptualised.

5

6 **Keywords:**

7 Pastoralism – Ethiopia – Invasive Species – Sustainable Livelihoods – Wellbeing – Socio-  
8 cultural impacts

9

10 *“A Gini (devil spirit) has come and settled in the Prosopis thickets. He feeds on the seed  
11 pods and then attacks us”*

12 - Hasoba kebele

13 **Background**

14

15 In spite of a highly developed and generally harmonious relationship with their local  
16 environment, pastoralist communities around the world have faced, and continue to face, a  
17 range of non-climate and climate related drivers of vulnerability (López-i-Gelats, et al. 2016,  
18 Devereux and Tibbo, Social Protection for Pastoralists 2013). These non-climate related  
19 drivers, like natural resource, governance and policy factors, include those related to  
20 ‘unfavorable development policies oriented towards pastoralists’ resulting from the  
21 ‘persistence of unfavourable narratives’ and ‘governments’ desire to control pastoral groups  
22 and the resources present in pastoral land’ (López-i-Gelats, et al. 2016). The diversity and  
23 strength of such drivers has deepened the vulnerability of many pastoralist groups leading to  
24 reduced herd sizes, livelihood insecurity and reliance on remittances and aid (Devereux and

1 Tibbo, Social Protection for Pastoralists 2013, Little, et al. 2008, Livingstone and Ruhindi  
2 2013). Yet, it is also widely recognised that many pastoralist communities have multiple  
3 sources and manifestations of strength; they are often able to cope and adapt in the face of  
4 such adversity due to their local knowledge, mobility, interdependence and the existence of  
5 institutions to enable communal decision-making (López-i-Gelats, et al. 2016, Barrow, et al.  
6 2007, Fratkin and Mearns 2003).

7

8 Within this context of a diversity of sources and drivers of vulnerability the effects of invasive  
9 alien species (IAS) can be seen to further frustrate and challenge pastoralist livelihoods and  
10 wellbeing. IAS are species species that have not only become naturalized but thrive in their  
11 non-native environment, reproducing viable offspring and spreading a considerable distance  
12 from the introduction site (Pyšek, et al. 2004, Richardson, et al. 2000). However, as Kull et  
13 al. (2011) discuss, how invasive species are perceived and used varies significantly depending  
14 upon ecological, social and political context. Whilst the environmental impacts and  
15 economic effects of *P. juliflora* on pastoralist livelihoods in East Africa are well-documented  
16 (Wakie, Evangelista, et al. 2014, Mwangi and Swallow 2005), the breadth and depth of social  
17 impacts and responses have not been as widely reported on. The aim of the research  
18 reported on here was to address two questions: firstly, how are the impacts of *P. juliflora*  
19 perceived by pastoral communities in Afar? And, secondly, why are pastoralist communities  
20 so vulnerable to the impacts of *P. juliflora*?

21

22 To investigate the perceptions of impacts and why pastoralist communities are particularly  
23 vulnerable to the negative effects of an IAS such as *P. juliflora*, the research utilises two

1 complementary approaches, the Sustainable Livelihoods Framework (SLF) (Scoones 2009,  
2 Scoones 1998) and the Wellbeing in Developing Countries (WeD) approach (White 2010).  
3 The purpose of drawing on both is to benefit from the structure afforded by the asset-based  
4 analysis of sources of vulnerability in the SLF to individuals or households and to deepen that  
5 analysis through generating data on how *P. juliflora* affects perceptions of wellbeing. The  
6 interrelationship between personal, social and environmental impacts and assets receives  
7 specific attention. This paper focuses on the five types of assets (economic, natural, physical,  
8 human and social) which shape a sustainable livelihood and whose contribution to livelihood  
9 strategies and outcomes are mediated by a range of policies, institutions and processes. It  
10 then draws on WeD, which complements the asset-based analysis found in SLF by focusing  
11 on relational and subjective dimensions of wellbeing, reflecting the importance of social  
12 relations for wellbeing and the observation that personal perceptions affect wellbeing and  
13 livelihoods (White 2010).

14

15 Through this novel application of the SLF and WeD, the article makes two contributions to  
16 literature. The first is to demonstrate the depth and interconnection between impacts of an  
17 IAS on pastoralist communities, thereby illustrating their particular vulnerability to the  
18 negative effects of IAS. The second contribution is the complementary use of the SLF and  
19 WeD to enable a deeper, more holistic understanding of social impacts, implications and  
20 responses. A more nuanced understanding of how sources and drivers of vulnerability  
21 interact illuminates a wide range of interconnected impacts and implications.

22

1 The article examines the relationship between the invasive species *P. juliflora* and pastoralists  
2 in eastern Ethiopia. A very aggressive invader, *P. Juliflora* is a 'conflict species', conferring  
3 benefits (Pasiiecznik, Harris and Smith 2004) as well as costs, and has been present in Africa  
4 for over 100 years (CABI 2011). It was actively introduced in the 1970s and 1980s by  
5 governments and development professionals in East Africa to provide fuelwood and  
6 regenerate arid regions (Odour and Githioni 2013, Muturi 2012, Muanda, et al. 2009, Mwangi  
7 and Swallow 2005), although in Ethiopia there is a lack of clear documentation relating to its  
8 exact introduction pathway (Mehari 2015). The extensive invasion in the study area in eastern  
9 Ethiopia now affects a considerable, and growing, portion of Afar (Wakie, Evangelista, et al.  
10 2014, Haregewyn , et al. 2013, Tilahun and Asfaw 2012). Whilst studies exist on a local level  
11 stressing the environmental and economic impacts (Muanda, et al. 2009, Mwangi and  
12 Swallow 2005), articulation and exploration of the social impacts are generally absent.

13

14 The Afar experience many of the challenges common to other pastoralist groups, suffering  
15 development interventions that are often culturally insensitive (Berhe and Adaye 2007) and  
16 at times wilfully deleterious to local norms and practices (Bereketeah 2014). Common  
17 pastureland in eastern Ethiopia is already under pressure, frequently appropriated by  
18 external cotton and sugarcane plantations (Behnke and Kerven 2013), with the allegation  
19 that a formal judiciary offers limited recourse for resolving grievances (Mulatu and Bekure  
20 2013). The approach to pastoralism by successive Ethiopian governments has been to coerce  
21 or force people out of pastoralism into purportedly modern and efficient activities through  
22 the pursuit of large-scale commercial agriculture, the establishment of national parks and  
23 sedentarization (Gebeye 2016). Gebeye (2016) claims that none of these approaches were

1 successful or appropriate for pastoral priorities and needs. Notwithstanding the 2011 Afar  
2 National Regional State Proclamation, articulating institutional responsibilities (Chekol 2014)  
3 and establishing regulations intended to control, manage and eradicate *P. juliflora* in the  
4 region (Ali 2015), such a policy environment frustrates the formulation of an appropriate  
5 response to the pastoral impacts of invasive species.

6

### 7 ***Drivers of pastoral vulnerability***

8

9 The pastoral context in Eastern Ethiopia and the characteristics which render pastoralists  
10 vulnerable to environmental change are the subject of significant study, with the concept of  
11 vulnerability used to describe 'states of susceptibility to harm, powerlessness, and  
12 marginality of both physical and social systems' (Adger 2006). There is evidence of their  
13 sensitivity to global economic shifts, including food price spikes (Makki 2012) and to  
14 changes in the domestic political economy and specifically the state's interventions in driving  
15 enclosure (Lavers 2012). However, how these broader drivers, like sedentarization,  
16 marginalization and fractured state relations, interact with local and regional ecological  
17 considerations is poorly understood.

18

19 Sedentarization can be seen as both a driver of vulnerability and a solution to vulnerability  
20 for pastoralists (Galvin 2009). In terms of increasing vulnerability, when sedentarization has  
21 been led by the state or forced upon pastoralists through land grabbing or drought, this has  
22 reduced land rights, eroded customary institutions and harmed livelihoods (López-i-Gelats et  
23 al., 2016; Schmidt and Pearson, 2016). As sedentarization erodes pastoral institutions,

1 communities become increasingly exposed to conflict (Barrow, et al. 2007). However,  
2 sedentarization can also be adopted as an adaptation strategy in the face of climate change  
3 or incidence of livestock disease, or adopted in response to incentives (Galvin 2009).

4  
5 The capacity of pastoral communities to adapt to changing ecological conditions is  
6 compromised by their diminished economic and political standing, and hence  
7 marginalization. The external imposition of change and adaptations (Tsegaye, Vedeld and  
8 Moe 2013) drives pre-existing tension and distrust between the government and local  
9 communities (Rettberg 2010) and political marginalisation. This contributes to a diminished  
10 indigenous capacity to manage risk, and the poor accounting of social capital leads to  
11 misrepresentations of the types of risk communities face (Davies and Bennett 2007).

12  
13 This disenfranchisement between state and pastoral communities is presented as a  
14 significant cause of pastoral marginalisation and vulnerability. Undermined customary  
15 institutions operate in a context which has "diminished the strength of leaders and  
16 empowered the government" (Schmidt and Pearson 2016, 29). This power imbalance  
17 leads to a perception of "declining legitimacy" (Burgess 2009, 96) and potentially positions  
18 the state as a cause of rather than solution to the challenges local communities face and  
19 strengthens a narrative which casts it as "illegitimate and ignorant" (Rettberg 2010, 271) .  
20 The state's "nominal" (Markakis 2003, 452) presence compromises its ability to manage  
21 conflict and to assimilate, reflect and represent communities and the challenges they face in  
22 peripheral areas, though more attention needs to be paid to the drivers of, and solutions to,  
23 this disengagement.



1

2 Pastoralism is a source of factors which build resilience and decrease vulnerability. An  
3 abundance of indigenous local pastoral knowledge is a strength *per se* and in developing  
4 adaptation strategies (Luizza, et al. 2016), although significant environmental change  
5 challenges an epistemology so embedded within its ecological context. In areas that are not  
6 congruent with other forms of livelihood activities (Tsegaye, Vedeld and Moe 2013)  
7 pastoralism holds significant economic advantages, although centralised development and  
8 political processes frequently overlook these.

9

10 This brief review of drivers of pastoral vulnerability highlights the complex and nuanced  
11 relationship between environmental stress and conflict, the lack of understanding of how the  
12 erosion of pastoral institutions and sedentarization contribute to increased pastoral  
13 vulnerability, the different framings of vulnerability to invasive species and the  
14 disenfranchisement between state and pastoral communities. The complexity of such drivers  
15 informed the research design, the data collection tools and data analysis.

16

### 17 ***Pastoralism and P. juliflora***

18

19 *Prosopis juliflora* and the variety of impacts associated with its invasion present another  
20 driver of pastoral vulnerability. Costs include changing local environments, where reduced  
21 biodiversity translates into the loss of culturally valuable indigenous species in Kenya (Stave,  
22 et al. 2007), and in Southern Afar is linked to the loss of livestock forage and fodder. (Mehari  
23 2015). Drawing on participatory research, Wakie et al. (2016) also highlight the perceived loss

1 of native species in Southern Afar, in addition to increased livestock morbidity and mortality  
2 and a loss of indigenous culture. Both studies use diverse methodologies to illustrate a range  
3 of inter-related costs that contribute to pastoralist displacement and the promotion of  
4 unpopular management practices in eastern Ethiopia (Kebede and Coppock 2015).

5

6 However, *P. juliflora* is perceived as both a negative and positive introduction, and  
7 perceptions, and priorities, vary between elite agents and local communities, as the court  
8 case launched by pastoralists against the Kenyan government over the invasion of their  
9 grazing lands demonstrates (Kenya Law 2006). There is a need for evaluative frameworks  
10 with the sensitivity to arbitrate these varying perceptions (Muanda, et al. 2009) and a nuance  
11 which can recognise how management strategies are mediated by issues like land tenure  
12 and how perceived impacts differ based upon livelihood activity (Shackleton, Maitre and  
13 Richardson 2015). The relationship is complex and at times contradictory; analysis of the  
14 impacts of *P. Juliflora* in eastern Ethiopia by Zeray et al. (2017) found the invasion increased  
15 income from crop production and off-farm activities whilst reducing income from dairy  
16 production, and, in South Africa, Shackleton et al. (2015) conclude that land users accessing  
17 common property resources recognise the perceived costs but are less focused on  
18 management than private landowners. In pastoral areas of Kenya both direct and indirect  
19 economic costs and benefits of *P. juliflora* have been studied and documented (Mwangi and  
20 Swallow 2008) and illustrate the idea of *P. juliflora* as a 'conflict' species (Haregewyn , et al.  
21 2013). Resilience is also impacted by dependences upon specific ecosystem services (Ayanu,  
22 et al. 2015), dependencies which are culturally and socially moderated. Better documentation

1 of socio-economic impacts are said to improve understandings of pastoral vulnerability  
2 (Haregewyn , et al. 2013).

3

4 Pastoral environmental stewardship is not just a strength but a necessity, supporting  
5 ecosystems which demonstrate more biodiversity in grazed areas (Maitima, et al. 2009),  
6 managing livestock systems which offer greater productivity over ranching (Hesse 2009) and  
7 only posing a threat to wildlife through competition when resources are forcibly shared, with  
8 no clear evidence that pastoralism *per se* leads to "competitive exclusion" (Butt and Turner  
9 2012, 8).

10

11 Pastoralists in Ethiopia, then, face a series of obstacles; particular focus in this article is on the  
12 social, cultural and political challenges and how these interrelate with and are complicated  
13 by the presence of *P. juliflora*. The analysis is rooted in overlooked impacts and proceeds  
14 from a methodology which neither prejudices pastoralism as a livelihood pursuit nor its  
15 inherent vulnerability to invasive species, respecting the fact that facets engender resilience  
16 as well as vulnerability.

17

## 18 **Study Area**

19

20 Afar lies in the Northeast of Ethiopia and is a sparsely populated region of 1.4 million with  
21 87% of its population living in rural locations and 29.5% listed as pastoralists (Central  
22 Statistical Agency of Ethiopia 2014). Social indicators are poor for the region, with 85% of  
23 people never having attended school and 17% are literate (M 19.4% and F 14.6%). Its hot,

1 arid and dry climate (Kottek, et al. 2006) renders productive agriculture a challenge.  
2 Southern Afar provides an informative context within which to study the livelihoods impacts  
3 of IAS. *Prosopis juliflora* coverage is extensive within the Afar region and Haregewyn et al.  
4 (2013) estimate that by 2020 a third of Amibara woreda in Southern Afar will be covered by  
5 *P. juliflora*, with an annual spread of at least 20,000 hectares per annum, an alarmingly high  
6 growth rate (Tilahun and Asfaw 2012). Additionally, the Afar constitute one of the most  
7 significant pastoral groups in the Horn of Africa and are subjected to the marginalisation and  
8 misrepresentation which commonly confront pastoralists (Devereux and Tibbo, Social  
9 Protection for Pastoralists 2013). As such, given the significant presence of *P. juliflora* and  
10 the pre-existing potential for marginalisation, the study area is apposite and timely. Within  
11 the study area pastureland near the river Awash has been appropriated for both sugarcane  
12 and cotton plantations and taken out of the historic rangeland livestock systems, despite  
13 inconclusive economic and development benefits (Behnke and Kerven 2013).

14

## 15 **Methods**

16

17 In order to differentiate impacts and improve understanding of why they are experienced as  
18 they are by pastoralists this section initially focuses on introducing the value of using the two  
19 frameworks, the SLF and WeD, in responding to the research question and explains how  
20 these were developed into a unified framework.

21

22 Initially the impacts of *P. juliflora* on the lives of pastoralists are analysed across all five asset  
23 bases (economic, natural, physical, human and social) of the SLF (Scoones 1998). A focus on

1 the human and the social develops a clearer understanding of the direct and indirect effects  
2 of *P. juliflora* on health, education, skills and capabilities and secondary impacts on  
3 community, social networks and political position and capital. White's (2010) conceptual  
4 systematisation of wellbeing strengthens analysis to develop an understanding of the  
5 relationship between *P. juliflora* and pastoralists in the context of "the social structures and  
6 processes through which sustainable livelihoods are achieved" (Scoones 1998, 11-12).  
7 Practical components of WeD are used to focus analysis on *social* wellbeing (subjective  
8 perceptions of social, political and cultural identities, violence, conflict, state relations and  
9 network).

10

11 An adaptation of Bebbington's (1999) analysis (Figure 1) combined the SLF and WeD to  
12 explore both objective and subjective impacts and provided an evaluative space to phrase  
13 these appropriately. Through using both methodological approaches there is an opportunity  
14 to synergise existing research and record economic and environmental impacts of *P. juliflora*  
15 with the social and cultural context to better understand why impacts are felt as they are.  
16 WeD's focus on the relational (White 2010) enables a language of enquiry which can capture  
17 the subjective, lived reality of those of whose relationship with their environment, both  
18 physical and social, has been disrupted by *P. juliflora*, and explore how this disruption relates  
19 to other challenges and to the pastoral experience.

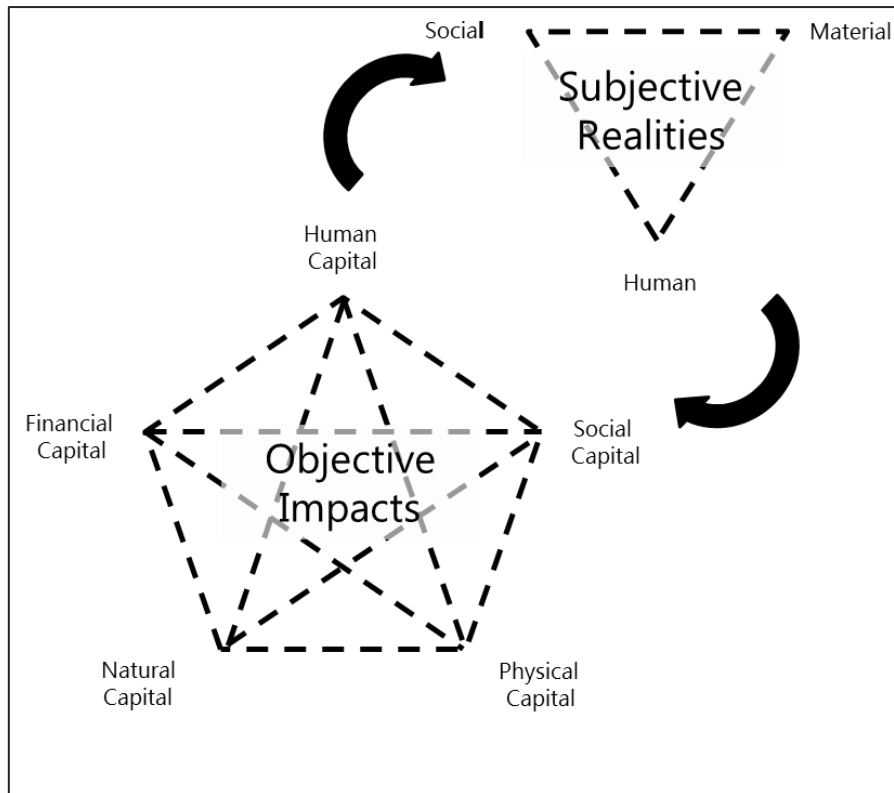


Figure 1: Measuring Human Impacts – the objective and the subjective

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A cross-sectional research design resulted in interviews with 77 pastoralists between January and April 2015 within 10 purposively selected communities, 6 in Amibara *woreda*, or district, and 4 in Gewane *woreda*. The specific locations within the study area in Southern Afar were selected with socio-economists at the agricultural research centre and local pastoral development officers on the basis of *P. juliflora* incidence. Perceptions of the problem, impacted assets, and management strategies, were discussed with all participants. In each *kebele*, or ward, equal numbers of men and women were selected by a *kebele* development officer according to gender and availability, given the transhumant practices of pastoralists,

1 to undertake a household questionnaire. The respondents then collectively participated in a  
2 focus group discussion which expanded and qualified specific themes. Interviews with  
3 community leaders, *kebele* administrators and 12 key informants representing inter-  
4 governmental organisations, Ethiopian government agencies and donors triangulated the  
5 household responses and established broader perspectives.

6

7 The individual interviews captured demographic data and focused on creating a  
8 comprehensive account of asset-based impacts and exploring the subjective impacts on  
9 wellbeing. The focus groups allowed triangulation of these impacts and how they impact  
10 capitals, wellbeing and relationships. Interviewing community leaders gathered qualifying  
11 data about community size and income to establish the scale of the issue and test the  
12 reported impacts at the community level. A discussion ensued about the asset impacts  
13 revealed during the interviews, social, political and relational dimensions of the invasion and  
14 the community's standing. Finally, proposed solutions and additional needs were discussed.

15

16 The sample of respondents was not selected on a random basis, but purposively selected  
17 based on likely familiarity with *P. juliflora*. The research objectives - to gain insight and  
18 understanding of and meaning from local impacts and perceptions and not to generate  
19 replicable, empirical data - support the use of purposive sampling. Token payments were  
20 made to participants as this has been normalised and compensate community members for  
21 their time. The researcher's role and how the research could support interventions were  
22 explained to address potential interview fatigue and frustration felt by respondents, and  
23 consent was gathered and recorded.

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## Results

### *The social and human costs to pastoral communities*

*Prosopis juliflora* impacts the environment as a lived space and is closely associated by participants with drought, changes to the water courses, specifically the river Awash, and a lowered water table. Drought augments the competitive advantage *P. juliflora* has in water deprived conditions to threaten indigenous species and reduced indigenous forage and pasture forces pastoralists to travel increasing distances to find suitable grazing. Pastures have been reduced to a "jungle" rendering grazing unsustainable in significant areas. It is not only drought but also the frequency and severity of flooding, as communities blame the weed for changes to water courses. The pastoralists view this battle as greater than the infamous struggles between Issa, a Somali clan, and Afar, and *P. juliflora* is likened to "HIV for the environment"(Female, 40s, Melka Sadi *kebele*). This level of pasture loss precipitates household poverty and the increasingly barren environment threatens an abandonment of the land, with invaded areas dismissed "as a shed for wild animals" (Male, 40s, Sarkamo *kebele*). Communities report an increasing proximity to wild animals. The presence of large carnivores like hyenas and lions, threaten livestock and children, a threat which is exacerbated when the increasingly difficult search for pasture causes the household head to spend longer periods away from the family.



1 The importance of the natural context stretches beyond the provision of livelihoods and  
2 economic resources. The local environment and biodiversity underpin a cultural heritage,  
3 demonstrated by a rich vocabulary and the diverse uses for the numerous indigenous plant  
4 species. The name of the same indigenous species subtly varies between *kebele*, and those  
5 *kebele* identified scores of indigenous plant species. However, a number of key informants  
6 expressed the view that *P. juliflora* benefits the environment through greening otherwise arid  
7 areas, and preventing wind erosion, impacts rarely echoed within the community.

8

9 *Prosopis juliflora's* interaction with the local economy is more varied and more nuanced, with  
10 frequent acceptance that there were benefits in the form of charcoal production. This leads  
11 to economic advantages, with reports that those engaged in charcoal production were  
12 sharing the economic benefits with pastoralists. However, this benefit has to be weighed  
13 against the perceived impoverishment of soil quality, and the environment more generally,  
14 and the potential for conflict between communities over how benefits and costs are divided  
15 between charcoal producers and pastoralists. Additionally, the view that *P. juliflora* charcoal  
16 is of inferior quality indicates that benefits are not universally appreciated. Milling, or drying,  
17 the pods for livestock fodder is another proposed use for *P. juliflora*. Despite a number of  
18 high profile projects looking at this form of utilisation, both directly and in the form of flour,  
19 very few respondents raised this and one community commented that, whilst important for  
20 feed, the destruction of local species and impact on access to basic services outweighed this.

21

22 In stark contrast, the economic costs of *P. juliflora* were counted by elders in terms of  
23 clearance and diminished livestock. The extent of these economic costs was established by

1 key informants, impacting both Afar and Ethiopian Somalia, stretching beyond Ethiopia into  
2 the wider Horn of Africa and undermining and devaluing the pastoralist "bank", livestock.  
3 Participants reported a marked change in prospects within communities living with *P.*  
4 *juliflora*, with the rich becoming poor and food insecure, little milk for domestic consumption  
5 or surplus to sell at market, and a consequent lack of cash to support education and food  
6 purchases. The community in Briforo summarised their own recent history as moving from  
7 being "ignorantly rich to educated but poor", a situation to which *P. juliflora* contributes. The  
8 cost of removal of *P. juliflora* is significant and in some cases untenable, leading to fears that  
9 farmland will be re-appropriated and leased to investors.

10

11 Daily livestock losses are significantly reducing herd size due to diminished and  
12 impoverished grazing; livestock is being lost and predated upon in the thickets and gastric  
13 complications and a jaw disease, known locally as *armako*, caused by the pod and thorns are  
14 presenting new ailments which the communities have little understanding or experience of.  
15 Morbidity, as well as mortality, is a critical issue, with the loss of local fodder and pasture  
16 species impacting the herd's milk yield. The thorns and pods of *P. juliflora* respectively cause  
17 blindness and lameness and digestive problems which significantly reduce the market price  
18 of cattle. Finally, diminished household capital compromises alternative livelihood  
19 investment opportunities and the remaining options, like wage labour and horticulture, fail  
20 to generate significant income.

21

22 *Prosopis juliflora* also burdens the infrastructure which supports pastoralism. Access is  
23 impeded as roads and tracks are narrowed and blocked, and the thorns render vehicles with

1 inflatable tyres susceptible to punctures. This limits opportunities to access markets as large  
2 vehicles cannot transport the livestock long distances and the herding options are  
3 complicated by the propensity to lose stock in the thickets as the roads become less and less  
4 clear. Both access to market and to services, including healthcare and education, are  
5 diminished. An alarming story of a woman giving birth by the side of the road as she was  
6 unable to reach the health centre was shared and there are frequent reports of children  
7 getting lost on the way to school. The schools themselves become invaded, forcing the  
8 organisation of clearance parties to restore playing pitches and access roads.

9

10 Communities and homes do not remain unaffected. Impeded access also cuts off and cuts  
11 up communities, increasing isolation and provoking conflict. Homes are damaged, with  
12 disturbance to the cement foundations both reported and evidenced. *P. juliflora* blocks and  
13 damages the complex irrigation infrastructure, including ponds and flood and irrigation  
14 ditches, which manage both excess and exiguous rainfall, mediating floods and droughts. An  
15 external perception of *P. juliflora* as a cheap housing material was not echoed within the  
16 communities. The lack of indigenous species impacts the supply of building materials,  
17 reducing traditional fencing and construction materials and encouraging corrugated houses.  
18 These are not as environmentally sensitive as the traditional Afar housing and are not as  
19 well-suited to the stifling climate.

20

21 The perceived impacts on human health cover both direct and indirect costs. Thorn injuries  
22 predominantly injure the feet due to the lack of protection given by the customary Afar open  
23 footwear, specifically to children and women whose role it is to collect firewood. These

1 injuries, if infected, can lead to a loss of limbs and blindness if the eye is caught, reducing  
2 individual, household and community income, exacerbated by the difficulties in accessing  
3 health services. There is further evidence of a disproportionate burden. A number of  
4 respondents, including the son of a women's development officer, noted the difficulty  
5 women have in accessing healthcare particularly during pregnancy. Children remain  
6 particularly vulnerable to the ill-effects of *P. juliflora* owing to a tendency to eat the pods,  
7 which causes throat infections, and their higher susceptibility to malnutrition and to suffering  
8 from a lack of milk. The health of pastoralists is further compromised by poor availability of  
9 traditional plant medicines and a reported increase in malaria in invaded areas.

10

11 As one community leader simply stated "if a family can't feed their children they can't attend  
12 school" (Sarkamo *kebele*, 50s). Impoverished access to schools is both physical, due to poor  
13 roads and the increasing need to move over longer distances to seek out pasture, and  
14 economic, as spending on control and eradication detracts from spending on education and  
15 other services.

16

17 Socially, dislocation, displacement and distance are undermining traditional Afar social  
18 norms and patterns of behaviour. Within communities *P. juliflora* acts like, in the words of  
19 one inter-governmental representative, a "barbed-wire fence" which forces a barrier between  
20 neighbours and limits the reconciliation of conflict. One community counted the cost of this  
21 displacement at 70 households who had migrated out of the community. In addition, the  
22 pressure on households forces internal displacement and short-term migration, both of  
23 which fracture community identity. The increasing distances travelled from the *kebele* to

1 find pasture cause the household to split more frequently and strain social processes like  
2 *dagu*, a “sophisticated system for news exchange” (Menbere and Skjerdal 2008, 19) which  
3 constitutes the traditional Afar means of communication across the rangelands.

4

5 Conflict is also a concern and exists on a variety of different levels. Within the community  
6 there are tensions between different clans over access rights and how costs should be  
7 shared. Pastoralists from invaded areas can find themselves in conflict with other  
8 communities who deny herds from invaded rangelands access to their pasture, although  
9 other communities do maintain customary traditions of reciprocity. Conflicts simmer with a  
10 range of groups outside the Afar communities; with the Issa where the increasing scarcity of  
11 productive rangeland adds fuel to pre-existing tensions, with charcoal producers who are  
12 generally seen as exploitative outsiders, with commercial plantations which pitch the  
13 pastoralists against the formalised bureaucracy and will of the state, and with NGOs who  
14 promote utilisation strategies perceived as inappropriate.

15

### 16 ***Pastoral perceptions of P. juliflora and their wellbeing***

17

18 Wellbeing, and an analysis of this, provides a pallet to illustrate the differences between  
19 objective and subjective perspectives. Generally imagined as existing across three realms,  
20 material wellbeing, human wellbeing and social wellbeing (White 2010), this analysis focuses  
21 on elements of social wellbeing, as this is the area where analysis using the frames of the SLF  
22 could be best strengthened. The social wellbeing of the community is assessed through

1 focusing on conflict, community standing and identity and pastoral relations with the state  
2 and other external agencies.

3

4 As discussed, conflict exists as a corollary of *P. juliflora* invasion and as a feature of Afar  
5 existence. As a phenomenon it illustrates the importance of taking a subjective approach  
6 which analyses relationships. Within communities the impacts of *P. juliflora*, and the conflict  
7 that flows from it, are experienced distinctly, dependent upon tribe, upon whether one is  
8 benefiting from charcoal production or not, and upon how these benefits are shared and  
9 used. Conflict between communities is influenced by the specific ecological context, the  
10 perceived risk, the strength of ties between tribe and community and the levels and  
11 effectiveness of government involvement. As a process that “happens in relationship” (White  
12 2010, 170), wellbeing forces appraisal of the fact that diminished access and damaged  
13 relationships between pastoralists contribute to the state of conflict and that poor  
14 communication between individuals and communities is an aggravating factor. When *P.*  
15 *juliflora* envelops rangelands it is difficult to determine which land belongs to which *kebele*,  
16 undermining how the community relates to its environment, and pitching community against  
17 community. Conflict underscores a diversification of phenomenological positions that occurs  
18 within a changing landscape and creates a juxtaposition of radically varying and fractured  
19 ontologies which, under increasing pressure from an existential threat, struggle to find a  
20 unifying epistemology.

21

22 The political identity and community standing of pastoral groups is altered by reduced herd  
23 size, the need to divert resources to clearance and general impoverishment. This stark

1 change in fortunes prompted the focus group in Gedeabora *kebele* to reminisce, "we were  
2 once rich and able to raise a lot of capital, but now the economy is deteriorating and we are  
3 losing capital". This is most acutely felt through the prospects for children for whom there is  
4 little hope. As a community leader ruefully remarked, the "children are continually asking  
5 what their fate is and their inheritance - the future of the community is at stake" (Halai Degi  
6 *kebele*, 80s). This sense of standing and stability is further undermined by displacement and  
7 resettlement of members, with those who do migrate finding it difficult to maintain their  
8 pastoral identity and those who remain living alongside charcoal producers with differing  
9 norms and practices. The changing relationship with milk, a particularly strong cultural  
10 signifier to pastoralists, was described by the Galila Dura *kebele* focus group thus:

11 "We previously provided milk to foreigners, but they can no longer do this as  
12 there is not even enough for our kids. We used to have to put it in the Awash as  
13 there was too much, and are now surviving on the past good times. This is a  
14 punishment from God."

15 The extent to which the community's standing has diminished is indicated by the fatalistic  
16 perception that this is some divine curse and the significance is marked by the conflation of  
17 two core tenets of Afar life, God and pastoral culture, symbolically represented by milk, to  
18 make some sense of this unfurling tragedy. Whilst there remains some faith in the  
19 community's capacity to respond, with support and resources from the state and NGOs, this  
20 needs to be weighted by the existential despair a significant number of pastoralists  
21 expressed, with some bemoaning their latter-day inability to be pastoralists. This diminishes  
22 their way of life and corrupts and impoverishes their culture, ultimately transforming their  
23 identity.

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This cultural *impasse* within which the communities find themselves is rooted in the (poor) health of the indigenous biodiversity. This once rich resource underpins Afar cultural identity, from provision of fodder and grass crops, to construction materials, medicines and personal hygiene aids like *adaito*, which is used as a toothbrush, and *casalto*, a leaf used to sooth and cool water to provide a refreshing tonic. The variety of species listed by the communities and the subtle differences in dialect between *kebele* over the study area indicate how important the natural resource base is in both supplying and underpinning an identity which is frequently as one with its environment. The consumption of milk, so culturally significant as a tool for social interaction, as a currency and, in the form of butter, as a product for conditioning and styling hair, is now spoken about as history, a history which, with the invasion of burial grounds and the destruction of statues by *P. juliflora*, is increasingly difficult for communities to preserve.

State relations are strained at a time when the pastoralists face increasing dependency on it for support, and it is accepted that financing a response to *P. juliflora* diverts funding from other sources. Communities do see a role for themselves, providing personnel to undertake clearance, but the government has to lead in providing technical expertise and technologies. However, *P. juliflora* limits interaction with the government, and hampers access to support and representatives, diminishing both the political power, and relevance, of communities and their development prospects.



1 The relationship of pastoralists with the government is complicated by attempts to manage  
2 *P. juliflora* through a variety of interventions. The policy towards charcoal production was,  
3 and still is, confused, firstly allowing production as means to utilise the crop and then  
4 banning it due to the environmental and social damage and limited economic benefit. There  
5 is still some dispute over whether, and where, production is controlled and a suspicion that  
6 charcoal producers are ignoring any restrictions. On a larger scale, there are a significant  
7 number of policies, frameworks and management strategies highlighted by key informants  
8 which were not mentioned at community level, suggesting that responses and solutions to *P.*  
9 *juliflora* exist at two different levels, one external and one local. Additionally, the  
10 government is required to arbitrate in conflicts, and is focused on high-level conflict between  
11 the Afar and the Issa with limited success. However they have established fora to arbitrate  
12 between aggrieved clans and communities and supported the customary fines issued for  
13 transgressions.

14

15 Interaction with NGOs focuses on clearance and utilisation projects, but notwithstanding  
16 these initiatives, and an expectation amongst pastoralists for NGOs to fill a gap left by the  
17 government, there is limited success due to scale. There is also a presiding view that as a  
18 foreign problem the solution should come from foreigners, and an increasing openness to  
19 foreign advice and suggestions amongst the most severely affected communities. This  
20 typifies a changing and an opening of attitudes, although it is difficult to promote as a  
21 positive development given that it is neither from a position of power or of any significant  
22 choice.

23

1 **Constructing pastoral vulnerability through the relationship between *P. juliflora* and**  
2 **other drivers and threats to wellbeing**

3

4 Returning to the literature, there are a number of contexts within which *P. juliflora* interacts  
5 with existing threats to the pastoral system and drivers of pastoral vulnerability, including the  
6 production system itself, conflict, sedentarization and poor state relations. These  
7 interactions collectively and holistically start to indicate why pastoralists experience the  
8 impacts of *P. juliflora* in the manner they do, and how it impacts formal and informal  
9 institutions to temper the traditional coping strategies and to (de-)construct resilience in an  
10 invaded context.

11

12 The most widely reported ill-effect of *P. juliflora* is on livestock, the “backbone” of the  
13 pastoral economy. Any threat to livestock places pastoral prosperity in peril but few impact  
14 livestock in multiple ways like *P. juliflora*. It decreases and devalues pastureland and  
15 exposes livestock to a variety of different threats, including theft and predation. In terms of  
16 an impact on livestock value, *P. juliflora* reduces the value of the herd across a variety of  
17 measures. Economic, productive and reproductive capacities are all diminished, as livestock  
18 command less value at market, yield less milk and suffer from increased disease which harms  
19 breeding ability, and mortality reduces herd size through disease, theft and predation. This  
20 raid on all of the various accounts within the pastoral bank increases exposure and the few  
21 alternative livelihood pursuits that do exist are themselves frequently threatened by the  
22 invasions.

23

1 Whilst normalised to a certain extent, the insecurity which conflict causes to communities  
2 means it cannot be simply dismissed as a "right of passage" (Meier, Bond and Bond 2007,  
3 718)(Meier, Bond and Bond 2007). *P. juliflora*, and the consequent resource scarcity and  
4 pressures, contribute to pre-existing conflict and tensions, and it exists as a *conflict* species  
5 beyond the simple conference of costs to some and benefits to others to determining and  
6 diminishing how these costs are divided and mediated. A position which normalises  
7 pastoralist conflict struggles to accommodate the variety of levels that current conflict exists  
8 on, and the significant pressure that it places on both communities and arbitrating  
9 institutions, both formal and informal. It also raises a significant, and concerning, question;  
10 when the study area around the middle Awash, which was traditionally a refuge during dry  
11 periods, is the locus of conflict, is nowhere safe?

12

13 Another complex and nuanced relationship is between *P. juliflora* and sedentarization. The  
14 majority of respondents were mixing livelihood strategies and none of the communities  
15 interviewed were fully nomadic, but pre-existing levels of sedentarization were exacerbated  
16 by *P. juliflora*. This situation erodes and fractures the communities and traditions of  
17 pastoralism. Despite a lessening of pure, transhumant practice, communities were still able  
18 to maintain herds and move them between ranges. Political sedentarization, with which the  
19 respondents have a nuanced relationship, pushes them down whilst *P. juliflora* pushes them  
20 in, resulting in a pressure and tension which increases susceptibility to conflict, to the point  
21 that communities feel suffocated. There is also a tendency amongst the pastoralist  
22 respondents to conflate issues, with the idea that the process of sedentarization, and the  
23 purported benefits like education, work with *P. juliflora* to impoverish them materially. How

1 these nuanced factors interrelate is complex, but the perception is that they are colluding to  
2 devalue the material existence of pastoralists, a perception which is enforced by the radical  
3 reduction in herd size and profitability.

4  
5 Economic impoverishment, conflict and social transformation all impact the adaptive  
6 capacity of pastoralists. The diminished economic standing, social health and community  
7 wellbeing undermine the ability of communities to adapt to change and their resilience to  
8 environmental threats, and fuel a widespread sense of despair and questioning over their  
9 wellbeing. Common questions around what it means to be a pastoralist indicate the ill  
10 health of pastoralism in southern Afar, and the lack of ready answers suggests a knowledge  
11 gap which exacerbates impacts and occludes solutions. The dependence on external actors  
12 to actually call and manage any response, and provide resources and a solution, questions  
13 the vestiges of pastoralist faith in the community's ability to respond to the threats they face.  
14 In terms of the community's ability to adapt, the invocation to *Allah* to deliver them from *P.*  
15 *juliflora* is more telling.

16  
17 One of the critical reasons why pastoralists are so vulnerable is that the state is perceived as  
18 unable to fulfil all of its obligations. The sanguine recognition that the cost of controlling  
19 and managing *P. juliflora* detracts resources from education and health represents the  
20 observation that the state's relationship with the pastoralists has limits. The idea of a centrist  
21 state disengaged from a peripheral population is supported by the promotion of confused  
22 (charcoal production), misaligned (utilisation and fodder strategies) and deleterious (land-  
23 leasing) strategies in the context of *P. juliflora*. This supports the idea of an essential

1 competition and conflict between the “centrifugal logic” of state-centric formalized  
2 bureaucracies and a “centripetal logic [which] proceeds in terms of relations, movements and  
3 flows of people, animals, resources and tradeable commodities” (Korf, Hagmaann and  
4 Emmenegger 2015, 885). However, there are instances where the two work together, in  
5 the form of clearance strategies and the development and testing of forms of utilisation, and  
6 the “bureaucracy” is addressing the lack of an effective strategy. Given the extent of the  
7 invasion and perceived need there is a case for exploring alternative options, such as  
8 biological control (van Wilgen and Richardson 2014). This requires a synergistic multi-  
9 stakeholder approach, as recognised explicitly by the key informants and inferred from the  
10 interviews with pastoralists, and presents the opportunity for meaningful, collective  
11 engagement with the issue. Whilst the state is engaged, it is essential to identify  
12 intermediaries, or *bricoleurs* (Cleaver, et al. 2013), in bridging the two worlds, and ensuring  
13 that the seeds of co-operation flourish and that distrust is not allowed to occlude the small  
14 shoots of hope.

15

16 The pastoralists have much to contribute to developing solutions. Their social systems and  
17 institutions, unique epistemologies and their environmental stewardship are traditional  
18 sources of strength and resilience but have all been undermined by *P. juliflora* with  
19 customary institutions critically endangered. The difficulty in sustaining *dagu* underscores  
20 deteriorating communication between pastoralists which threatens time-honoured  
21 institutions. Traditional markers, such as trees and rocks, are difficult to determine within an  
22 invaded landscape, and traditional practices, like allowing pastoralists from other areas  
23 access to pasture, are increasingly ignored. The loosening of the ties which hold pastoralists

1 together and support the vulnerable reduce opportunities to find a solution internally.  
2 Customary institutions which manage common property are viewed as unnecessary when  
3 there are few resources to arbitrate and increasingly, owing to distances covered and having  
4 to access unfamiliar pasture, grazing decisions are made unilaterally. However, there are still  
5 *fora* for making decisions related to common property and within some communities these  
6 have been strengthened owing to the increasing demand that scarcity places on them, and  
7 in relation to conflict there is a recognised need for the government to support the  
8 resolution process. Government brokered solutions tend not to offer long-term solutions  
9 and are wholly inappropriate when one of the aggrieved parties, in the case of commercial  
10 plantations and through a proxy, is the government itself.

11

12 Another traditional source of pastoral resilience is their traditional ecological knowledge.  
13 This is underpinned by the natural resource base, and, as this diminishes, so too does  
14 knowledge and a sense of power over and understanding of their environment. The  
15 increasing reliance on the government, NGOs and foreigners to supply a solution reflects this  
16 decline. The willingness to embrace suggestions of a solution, like an apocryphal herbicide  
17 in Amhara, suggests how far the communities have abandoned their indigenous expertise in  
18 the face of this foreign threat. The names that the local community have for *P. juliflora*,  
19 "devil weed" and "Derg weed", capture the ignorance, fear and other-worldliness with which  
20 it is viewed by the local community.

21

22 One of the principal features of pastoralism is some sense of environmental stewardship, of  
23 co-existence and co-evolution with the local ecosystem. Pastoralism is a system which has

1 been demonstrated to effectively co-exist with local environments and to support the  
2 maintenance of areas rich in biodiversity. Whilst the alternatives, mono-cropping,  
3 commercial plantations and small scale cash crops, fail to offer the same level of  
4 environmental protection, with no incumbency upon users to preserve the unique  
5 ecosystem, they do offer the prospect of better confronting the invasion, a fact which offers  
6 the most significant threat to pastoralists. The tragedy of the invaded commons is that all of  
7 the co-evolved, ecological sensitivity and specialism is a burden rather than a boon.

8

## 9 **Conclusion**

10

11 The perceptions and perspectives of Afar pastoralists in relation to the *P. juliflora* invasion  
12 illuminate a breadth and depth of impacts on many aspects of their lives. The diversity of  
13 and relationship between impacts highlights the complexity and severity of a threat which  
14 effects every element of the pastoral system of production, from the reproductive health and  
15 success of livestock, to their ability to access food and water, to the ease with which livestock  
16 can be taken to market. The diversity of impacts is only matched by their depth. As the  
17 backbone of the pastoral economy, livestock are increasingly broken by the presence of *P.*  
18 *juliflora* within the rangelands. The sense of despair and disillusion that the pastoral  
19 communities frequently voiced is supported by the reported figures of livestock deaths  
20 within the communities and amongst the experts, and the priority with which the key  
21 informants view the issue and the environmental and economic costs as captured within the  
22 literature. What the experience of pastoralists in Afar also illustrated was a series of  
23 neglected impacts, and how recognised impacts can have unforeseen consequences. The

1 reduction in economic output is well recognised in the literature (Lovell and Stone 2005,  
2 Pimental, et al. 2001) as a cost of invasive species, but this precipitates increasing difficulty in  
3 accessing basic services, and a more profound impact on the standing and identity of the  
4 community. Studies into the environment and ecology generally, and IAS specifically, would  
5 benefit from adopting methods and approaches which do more to engage with these assets  
6 and capitals, particularly when investigating areas where human activity is closely dependent  
7 upon the natural resource base and sensitive to changes within its composition, as is the  
8 case with peasant societies. There is significant value and relevance to indigenous expertise  
9 and knowledge in terms of understanding the local environment. By strengthening the  
10 analysis of impacts on society and culture, the unique epistemology of these curators of the  
11 rangelands is better appreciated, both supporting and challenging perceived truths related  
12 to the costs and benefits of *P. juliflora* as highlighted in earlier studies and as suggested by  
13 key informants. One example is the value of charcoal production; whilst pastoralists  
14 accepted that it could carry certain economic benefits these fail to advantage the  
15 communities interviewed.

16

17 In addressing the question of why the impacts are felt in the way that they are, a number of  
18 important interactions with other drivers of change in pastoral areas need consideration.  
19 Whilst "conflict" (Haregewyn , et al. 2013) is central to conceptualisations of many invasive  
20 species with differentiated impacts and conflict is, to a degree, normalised in pastoral areas  
21 (Meier, Bond and Bond 2007, 718), the introduction of an invasive species disrupts pre-  
22 existing patterns of behaviour and introduces conflict across different social scales, posing a  
23 direct challenge to initiatives which look to different forms of utilization, and different actors,



1 as a means of *P. juliflora* management (Birhane, et al. 2017). The tensions and erosion of  
2 customary norms and practices that are precipitated by sedentarization are accelerated by  
3 the invasion of *P. juliflora*, and contentious state relations (Barrow, et al. 2007) are placed  
4 under increased pressure by a call to action from all parties. All of these drivers share one  
5 feature, to existentially threaten existing institutions at a time when the dynamic and parlous  
6 context demands some ground rules. The vulnerability of pastoral institutions to external  
7 threats and how this exposes pastoralism itself is well documented (Barrow, et al. 2007); what  
8 an analysis of *P. juliflora* and the Afar pastoralists suggests is the extent to which pastoral  
9 systems, institutions and local indigenous knowledge are extremely sensitive to  
10 environmental change and the depth of the symbiotic relationship between pastoralist  
11 livelihoods and the environment they inhabit. The number of external interventions, whilst  
12 necessary, do not unflinchingly support pastoral interests or respond to pastoral concerns. The  
13 response from the state is at times muddled and uncoordinated, falling between deleterious  
14 policies which sponsor sedentarization, commercial farming and the introduction of non-  
15 pastoral livelihood activities into pastoral areas (Rettberg 2010, Burgess 2009) to one where  
16 the scale of the issue and the limitations of extant resources force the state into a peripheral,  
17 “nominal” presence (Markakis 2003). These conflicting narratives are further compounded by  
18 the number of state agencies and actors involved in pursuing a solution to the problem, a  
19 genuine pursuit which itself is inevitably hampered by narratives of dispute between state  
20 and pastoralists. Where responses do arise they tend to reflect an ecological  
21 conceptualisation of the issue, which is inevitably focused on management of the invasive  
22 species within a specific ecosystem, whilst the principal threats to the pastoralists all distil  
23 ultimately to a threat to their livelihood, their identity.

1

2 In order to accommodate these varied conceptualisations of how environmental factors  
3 interact with livelihoods, and why threats are perceived and experienced as they are, current  
4 methodologies and analytical frameworks need to be synergetic and open to working across  
5 and including expertise from diverse areas of studies and disciplines. The two frameworks  
6 utilised within this paper, the SLF and WeD, recognise the specificity of social and relational  
7 contexts (White 2010, Scoones 2009, Scoones 1998) and address the poor accounting for  
8 social capital in assessments of pastoral vulnerability (Davies and Bennett 2007). Not only  
9 are local perspectives embraced and promoted, the personal and subjective are prioritised to  
10 reframe how invasive species are imagined by those who are closest to the reality. By using  
11 both the SLF and WeD together there are two advantages. The temptation with the SLF to  
12 rank rather than to relate assets is tempered by the relational imperative of WeD, whilst at  
13 the same time preserving the fundamental ability of the SLF to bridge different ontological  
14 stances and generate a unifying epistemology, not merely across academic disciplines but  
15 also between outsiders and insiders, between expertise and experience and between the  
16 scientific evidence and the "lived" reality. The understanding of social and cultural impacts  
17 affords a distinction between "means" and "meaning" (Bebbington 1999, 2022) and contrasts  
18 a means of life and a way of life, enabling a language which gives communities a voice. The  
19 local perspective allows researchers and practitioners to promote sustainability,  
20 empowerment and a two-way knowledge flow for improved understanding and solutions.  
21 These new epistemologies, accommodating both scientific expertise and local experience,  
22 serve to challenge pre-existing conventions and expand our frames of reference, presenting  
23 the possibility for conceptualisations of and solutions to environmental drivers of

1 vulnerability which reflect the unique social context of those who occupy the environment.  
2 This "reimagining" of biological invasions can accept and include perspectives, like those in  
3 Hasoba *kebele*, which find a unique meaning in the idea of a *Gini* to express the extent and  
4 consequences of natural phenomena.

5

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