The use and value of wild harvested provisioning ecosystem services along a landscape heterogeneity gradient in rural South Africa

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ABSTRACT
Provisioning ecosystem services (PES) are typically crucial to rural livelihoods, especially in developing countries. However, the links between PES and local biodiversity or landscape heterogeneity are poorly explored. Here, we examined the extent of use and value of locally harvested wild, terrestrial and marine PES (such as wild foods, traditional medicines, firewood, building materials and others) in three villages (35–40 households per village) along a gradient of decreasing landscape heterogeneity. Households at the site with the highest landscape heterogeneity used a greater array of PES (9 ± 4) compared to the intermediate (5 ± 3) and least heterogeneous (0.9 ± 0.8) sites. This resulted in a significantly greater annual value of PES to local livelihoods at the most diverse site (US$2 656 ± 2 587 per household), compared to US$1 120 ± 1 313 at the intermediate site and only US$105 ± 193 at the least heterogeneous site. This study shows the importance of access to a diversity of landscapes and PES to support rural livelihoods, which is frequently overlooked in PES valuation studies and in situations of land use change where landscape heterogeneity may decline.

Introduction

It is now well appreciated that ecosystem services are vital for human wellbeing and welfare (Millennium ecosystem assessment 2005; Fisher et al. 2014; Daw et al. 2016). However, the nature and extent of reliance on ecosystem services vary according to human needs, worldviews, cultures and local socioeconomic contexts. For example, for most people, albeit not all, in Global North countries forest experiences are about recreation and mental health, whereas in Global South contexts they may be valued more for provisioning services, but not exclusively so.

Provisioning ecosystem services (PES) provide a particular suite of consumptive goods such as foods, building materials, traditional medicines, decorative items and raw materials for crafts and utilitarian household items (Millennium ecosystem assessment 2005). In urban and Global North contexts such goods are usually purchased by consumers after having been transported from where they are produced to where they are consumed. In contrast, rural communities around the globe obtain a significant proportion of their daily needs and income from landscapes in proximity to where they live. For example, Shackleton and De Vos (2022) estimate that 2.8 billion rural people in the Global South regularly use one or more locally obtained non-timber forest products (NTFPs) which correspond to PES. In such instances, the relationship between human wellbeing and nature is a lot more direct, immediate and visible. This is evident in the appreciable proportion of household income (cash and non-cash) that is derived from locally available PES. For example, L’Roe and Naughton-Treves (2014) reported that locally procured PES provided 64% of household income to forest dependent households in Peru, whilst in northwest Zambia it was 44% (Kalaba et al. 2013) and southern China, 32% (Hogarth et al. 2013). Indeed, expressing the use and reliance on locally available PES in monetary or proportional terms can provide a telling indication of their importance to rural livelihoods and poverty alleviation strategies which is then useful for policy and decision-makers (Bastian 2013). The high reliance on locally available PES may be magnified several-fold during adverse times and shocks (such as droughts, pest outbreaks, death or retrenchment of breadwinners, armed conflicts) reflecting the vital safety-net role of PES (Mugido and Shackleton 2017). For example, Wunder et al. (2014) reported from a cross-country study that 65% of rural households had reported at least one shock over the previous year and 44% of these had turned to PES as a safety-net (although not necessarily as their first coping response).

Although the bulk of PES collected by rural households tend to be for direct consumption, the sale of PES also provides an important means for many rural individuals and households to generate cash income...
and maybe escape poverty (Fisher et al. 2014;Pullanikkatil and Shackleton 2018). A diverse range of PES are sold in raw form or after some value-addition processes, and are sold primarily in local or regional markets (Scherr et al. 2004; Mahony et al. 2019). The local trade of PES is growing with more people taking advantage of the low entry barriers and the opportunity to generate cash incomes, particularly during periods of income shortage (Shackleton et al. 2008). For example, the sale of beer brewed from marula fruits (Sclerocarya birrea) in Limpopo Province, South Africa, generated a modest income but came at an important time of year when there was high demand for cash for school fees, books and uniforms (Shackleton and Shackleton 2004).

The typically strong and direct relationship between livelihoods, wellbeing and locally available PES makes many rural populations particularly sensitive to some degree of change in the abundance or nature of local biodiversity or access to it, although longitudinal studies of such are limited (Angelsen and Dokken 2018; Falayi et al. 2019). For example, land transformation or homogenisation can result in trade-offs and loss of valued PES, resulting in reduced livelihood or wellbeing (Shackleton 2020), although analyses of trade-offs for wild harvested PES are relatively scarce (Lee and Lautenbach 2016; Brockerhoff et al. 2017). Indeed, it is widely accepted that more biodiverse and heterogeneous landscapes offer a greater range of ecosystem services and resilience than more homogenous ones (Schippers et al. 2015; Knoke et al. 2016; Oteros-Rozas et al. 2018). However, the evidence for this relationship has rarely included PES or been examined in contexts where there is a strong reliance on PES for direct household welfare.

The nature of the relationship between biodiversity and ecosystem services is complex and spatially and temporally variable. Indeed, species diversity alone is not a good predictor of ecosystem services (Schuler et al. 2017). Rather, habitat diversity or landscape heterogeneity play a greater role in ensuring that a range of ecosystem services are available (Syrb and Walz 2012; Pendleton et al. 2020), not least because of the generally positive relationship between habitat diversity and species richness at landscape scales (Kumar et al. 2006; Priego-Santander et al. 2013) up to a point (Ekroos et al. 2013). Yet, Sutherland et al. (2016) argue that most inventories of ecosystem services fail to acknowledge this and therefore tend to simplify results across landscapes rather than identifying the role of landscape heterogeneity in ecosystem service supply. This may be particularly problematic for PES in contexts of strong and direct reliance for a variety of livelihood needs and poverty alleviation (Fisher et al. 2014). Even more so in contexts where landscape heterogeneity declines. For example, through expansion of monocrop agriculture or plantations (e.g. Ribeiro Palacios et al. 2013), loss of wooded areas due to deforestation (Hernández-Ruedas et al. 2014), or landuse intensification (Iacopino et al. 2022).

Within this context, the objective of this study was to quantify and compare the extent of use of locally harvested PES along a gradient of landscape heterogeneity in a rural region of South Africa. In doing so, we sought to answer the following research questions: (1) what locally harvested PES are used at each site? and (2) what is their monetary value to local livelihoods? Our central hypothesis was that households living at the site with the greatest landscape heterogeneity would make use of a greater diversity of PES and to a greater extent, than those in less diverse landscapes. In this study, we took PES to be locally produced biological resources (i.e. excluding water and sand/clay) harvested or collected by the residents in and around the three study villages.

**Study area**

The study was conducted in three rural villages situated along a gradient of decreasing agroecological potential (from the coast inland) and landscape diversity in the Transkei region of the Eastern Cape province, South Africa (Figure 1). The coastal village Njela (31°44’16”S; 29°22’26”E) lies approximately 18 km from the R61 road that links the town of Mthatha to Port St Johns, the closest urban hub. Gogogo (31°43’11”S; 29°17’00”E) and Ludaka (31°39’21”S; 29°08’09”E) are situated further inland towards Libode, roughly 15 km and 56 km from Njela, respectively.

Biophysically, the landscape consists of gently undulating hills and valleys, with the altitude ranging from sea level at Njela to 600 m at Ludaka (Table 1). The mean annual rainfall ranges between 1 015 mm at Njela on the coast and 717 mm further inland at Ludaka and is concentrated in summer (October – April), although some rain in winter is common. Mean temperatures range from highs of 30°C in summer, to lows of 10°C in winter (Mucina et al., 2006). Njela falls within the Transkei Coastal Belt (Mucina et al. 2006) characterised by a grassland-woodland-forest mosaic. The grasslands generally occur on the hill crests, with forests in the valleys and an uninterrupted belt of coastal dune thicket along the coast. There are eight distinct natural landscapes at Njela, namely forests, woodlands, grasslands, marine, estuarine, riparian and old fields (in varied states of succession). Approximately 80% of the terrestrial land surface is under forest, woodlands or old fields with invading shrubs and trees (Herd-Hoare 2018). Gogogo falls within the Ngongoni Veld vegetation type, typified by dense grasslands of low
species diversity dominated by *Aristida junciformis*, with forest patches in the valleys (Mucina and Rutherford 2006). Here there are three broad ‘natural’ landscapes, namely, grasslands, small forest patches and old fields with invading shrubs and trees. About 40% of the landscape is wooded (at varying densities). Ludaka is primarily situated in Bisho Thornveld with one ‘natural’ landscape, that is, grasslands with very few, scattered small trees, such as *Acacia natalitia* (Mucina and Rutherford 2006), but there are no discernible wooded landscapes (Herd-Hoare 2018).

Gogogo is the largest village with 951 people (206 households with an average of 8 ± 4 (SD) people per household), followed by Ludaka with 685 (144 households with an average of 6 ± 3 people per household) and Njela with 460 (85 households with an average of 7 ± 5 per household) (Table 1) (Statistics South Africa 2011). The youth (age 0–19) are the largest group, comprising more than 59% of the population in each village, with less than 6% of the population being pensioners (>65 years) (Statistics South Africa 2011).

Each village is under communal tenure, where land is categorised into arable lands, residential plots with adjacent home gardens, and communal rangelands which are used for grazing and the harvesting of natural resources (wild/spontaneous

Table 1. Socio-economic and biophysical profile across the three villages (From: Statistics South Africa 2011 and baseline data from household surveys).

| Category                                      | Njela          | Gogogo         | Ludaka         |
|-----------------------------------------------|----------------|----------------|----------------|
| Population                                    | 460            | 951            | 685            |
| Households                                    | 85             | 206            | 144            |
| Average household size (people) ±SD           | 8 ± 4          | 7 ± 5          | 6 ± 3          |
| % HH with livestock                           | 29             | 53             | 70             |
| Mean size of home garden (ha) ±SD            | 0.13 ± 0.10    | 0.12 ± 0.02    | 0.21 ± 0.06    |
| % female-headed households                    | 59             | 58             | 58             |
| Modal level of education                      | Primary        | Primary        | Primary        |
| Modal household income bracket (Rand per year) | 9 600–19 600   | 9 600–19 600   | 9 600–19 600   |
| Main source of household water                | Dam/pools      | River/stream   | River/stream   |
| Mean annual rainfall (mm)                     | 1 050          | 840            | 717            |
| Altitude (m)                                  | 0              | 430            | 600            |
| Broad landscape types                         | Forest, woodland, grassland, marine, estuarine, riparian, old fields | Grassland, forest, old fields | Grassland |

Rand to US dollar value during data collection was approximately US$1 = R15.00.
resources might also be harvested from gardens and fields, such as wild herbs and mushrooms). Land is allocated by headmen on behalf of traditional chiefs. Most households have electricity, but none have water reticulation. Households in Gogogo and Ludaka rely on river or rainwater, and people in Njela rely on a dammed pool for water. Some households harvest rainwater via gutters into storage tanks. Fuelwood is the dominant source of energy for cooking and heating, while lighting is primarily from electricity.

Formal economic activity in each village is low. The modal household income bracket in each village is R9 601–19 600 per annum (US$640–1 307), with more than a quarter of households falling within the ‘no income’ bracket (Statistics South Africa, 2011). Most households engage in multiple livelihood activities with various combinations of livestock husbandry, cultivation of home gardens and maybe fields, collection of wild natural resources, and with some cash income sources. Cash income sources include government social grants (>95% of households), small businesses (e.g. thatching, hairdressing, mini-retail stores, sale of locally collected natural resources, etc.) and formal employment (31% of households in Njela, 15% in Gogogo and 8% in Ludaka) (Herd-Hoare, 2018). Formal education levels are low, with only a few advancing beyond primary school. Other than the slightly larger household size at Njela, the profile of the sample households is typical of the rural areas of the broader municipality in which they are situated (Port St Johns Municipality, 2021) and that part of the Eastern Cape (e.g. Ncube et al. 2016; Hadju et al. 2020).

**Methods**

We adopted a mixed methods framework combining focus group discussions (FGDs; using a range of Participatory Learning and Action (PLA) activities), transect walks, structured household surveys, and key informant interviews. There was a large degree of triangulation between methods to support the same objective. Field work was conducted between late 2016 up to mid-2017. Interviews and discussions were conducted in the local language, isiXhosa, and interpreted simultaneously. Ethics clearance was granted through Rhodes University (ES16/1).

**Group and participatory approaches**

Between five and seven FGDs, approximately four hours in duration, were conducted in each village. Each FGD consisted of different groups of people (6–12 residents) within the community, namely (a) cultivators of different ages and genders (b) the elderly, (c) the youth, and (d) specific PES users. FGD participants ranged in age between 21 and 80 years old. Participants for each FGD were nominated by the village headman. Following Schreckenberg et al., (2016) a range of PLA methods were used in each of the first three FGDs including (a) trendlines – which demonstrated the perceived change in landscapes, landuses and PES since the 1950s, (b) seasonal calendars – which identified the seasonal variations in each PES, (c) participatory mapping – which highlighted the harvest locations of the highest ranked PES on a projected Google Earth image of the village (this tool was primarily used to stimulate discussion rather than a means to generate a visual map), (d) ranking exercises – which developed ranked lists of specific PES listed according to specific criteria such as frequency of use and amount used (Herd-Hoare, 2018). Historical timelines were done in FGDs with the elderly.

Transact walks were undertaken with participants in each village who were deemed knowledgeable on each land-based livelihood sector. This allowed for collection and identification of key plant species mentioned in FGDs, clarification of any uncertainties in a more informal and familiar setting, the location of key features and resource areas depicted during the participatory mapping, and a general opportunity to better understand the spatial layout of the village, surrounding landscapes and their associated access routes.

**Key informant interviews and household surveys**

Semi-structured, key informant interviews were conducted with each village headman, members of each village committee, and key individuals who specialised in the use or harvest of a particular PES. Questions were based on uncertainties derived from household surveys, FGDs or transect walks to gain additional understanding of PES use.

A household survey was undertaken in each village to capture the types and quantities of PES collected. Forty-one percent of households in Njela (35 households), 20% in Gogogo (40 households) and 28% in Ludaka (40 households) were randomly selected (after numbering households on an aerial photo). Household heads were the primary source of information but often delegated to another member for specific questions and for some there was a collective discussion and response. A household was taken as a person or group of persons who live together and make common provision for food or other essentials for living (United Nations, 2008). The questionnaire had two sections. The first collected data required to calculate the direct-use values of PES harvested from local environments. The surveys were modified in each village to include PES locally available for collection within the specific village boundaries.
(including wild resources spontaneously growing in fields and gardens). For example, ocean resources were not included in Ludaka which was primarily grassland. This included a checklist of all the wild harvested PES. Details included the frequency of harvest (number of times a week/month/or seasonally) over the number of months (to account for seasonality), the typical volume of the harvest, and farmgate prices. Where necessary local units were converted to conventional measures. Taking into account the production period, the mean annual direct-use value for each PES was calculated by multiplying the annual harvest by the average farm-gate price. Mean values were calculated across both user households and also all households (i.e. across user and non-users). The opportunity costs of family labour were not deducted in the context of high unemployment in the area translating into few opportunities for external labour. Thus, all reported values are gross values. The Rand to US dollar value during the time was approximately US$1 = R15.00.

The last section captured details of the socio-economic characteristics of the household. This included local human wellbeing indicators such as type of house, number of appliances, sources of income from formal, casual or self-employment and social grants, as well as age, level of education and number of years spent in the village of the household head, and household size.

**Data analysis**

Data were expressed in descriptive statistics, and means are expressed with their associated standard deviation (SD). Statistical analyses were conducted in R version 3.4 (R Core Team 2013). A one-way ANOVA was employed amongst normally distributed data to test the significance between the means of the three villages, and if significant, were followed by a Tukey post-hoc test. Regressions were used to test the relationship between number of PES and the economic value obtained. When comparing the value results obtained in this study to those of previous studies in South Africa, the earlier values were adjusted to 2017 values.

**Results**

**Range and extent of use of PES from local environments**

Across the sample, PES use was a common activity with all households in Njela, 95% of households in Gogogo and 63% of households in Ludaka, harvesting at least one PES product per annum. Although use of PES was widespread, the number of PES procured per household varied between villages, and decreased along the landscape heterogeneity gradient, with Njela harvesting the greatest number of PES and Ludaka harvesting the fewest. This was largely associated with location and proximity of the village to PES-rich landscapes. For example, in Njela, which was close to multiple landscapes, an average of 9 ± 4 PES were harvested per household (including coastal PES). In contrast, Gogogo and Ludaka, which had proximate access to fewer landscapes, collected 5 ± 3 and 0.9 ± 0.8 PES per household, respectively.

Patterns of resource use were similar in Njela and Gogogo. The most widely used terrestrial PES were fuelwood, indigenous poles, thatch grass and wild fruits that were collected by more than half of the respondents in these two villages (Table 2). Ranking exercises in these villages also emphasised the frequent collection of other products such as medicinal plants and wild herbs. The least collected PES were bushmeat, palm fronds, wooden utensils and wild honey. We acknowledge that the use of bushmeat might have been under-reported due to it being regarded as an illegal activity. In Ludaka, only two PES, namely grass for hand-brushes and thatch grass for roofing were collected by <50% of households and therefore the following sections report on PES in Njela and Gogogo only.

Fuelwood dominated in terms of frequency of collection and amount harvested. On average, two head-loads (typically 20–30 kg each) of fuelwood were collected twice a week by 97% of households in Njela and 83% in Gogogo. Residents believed that the availability of fuelwood in each village had not changed over the last 50 years and related this to the rapid re-establishment of Vachellia karroo in old field sites. This meant that women did not have to walk far to collect fuelwood. *V. karroo* was unanimously identified as the preferred fuelwood species because ‘it is strong, burns for a long time and is easy to access’. Despite the continuous use and availability of fuelwood, there was a perceived decline in reliance on fuelwood since the 1950s. This was explained in FGDs as a consequence of the introduction of paraffin into the area in the 1970s, gas in the 1980s, electricity in the 1990s and inter-generational changes such as young girls currently being reluctant to collect fuelwood and live an ‘out-dated’ way of life. This was despite the association of fuelwood collection as a qualifying factor of being a traditional isiXhosa female. The sale of fuelwood also represented an important source of income to some households, particularly in Gogogo, which was conveniently placed along the main road to villages with limited local fuelwood sources, such as Ludaka.

Although ranking exercises highlighted that thatch grass and indigenous poles were collected less frequently than other PES, each was collected in large quantities in Njela and Gogogo (i.e. >200 bundles of
Table 2: Prevalence of use (% of households) and average annual contribution of PES to rural households (self-collected use) (Rand to US dollar value during data collection was approximately US$1 = R15.00. (¹ High trade by a few individuals ²) Details of marine resources in Table 4.

| Resources                  | % of HH | Avg. annual direct-use and trade value per user HH (R/yr) | % of HH | Avg. annual direct-use and trade value per user HH (R/yr) | % of HH | Avg. annual direct-use and trade value per user HH (R/yr) | Av. annual direct-use and trade value across villages (R/yr) | Av. annual direct-use and trade value in all HH across villages (R/yr) |
|----------------------------|---------|----------------------------------------------------------|---------|----------------------------------------------------------|---------|----------------------------------------------------------|-------------------------------------------------------------|---------------------------------------------------------------|
| Bushmeat                  | 11      | 3 052 ± 3 496                                           | 8       | 5 933 ± 3 754                                           | 0       | -                                                        | 4 287 ± 3 630                                                | 216 ± 1 240                                                   |
| Fuelwood                  | 97      | 3 744 ± 3 404                                           | 83      | 8 807 ± 8 296                                           | 0       | -                                                        | 6 238 ± 6 759                                                | 3 635 ± 5 999                                                 |
| Grass hand-brushes        | 51      | 53 ± 77                                                 | 45      | 53 ± 77                                                 | 48      | 356 ± 599                                               | 158 ± 380                                                   | 76 ± 273                                                     |
| Marine resources¹         | 83      | 37 407 ± 33 559                                         | 0       | -                                                        | 0       | -                                                        | -                                                          | -                                                            |
| Mushrooms                 | 34      | 50 ± 166                                                | 63      | 52 ± 58                                                 | 0       | -                                                        | 51 ± 79                                                    | 16 ± 50                                                      |
| Palm fronds               | 14      | 1 534 ± 2 146                                           | 5       | 1 030 ± 1 371                                           | 0       | -                                                        | 1 390 ± 1 856                                               | 84 ± 541                                                     |
| Poles (fence)             | 66      | 2 532 ± 7 837                                           | 60      | 566 ± 581                                               | 0       | -                                                        | 1 573 ± 5 645                                               | 588 ± 3 511                                                   |
| Wooden Fighting¹          | 0       | -                                                        | 18      | 3 786 ± 3 029                                           | 0       | -                                                        | 1 376 ± 3 029                                               | 84 ± 770                                                     |
| utensils                   | 0       | -                                                        | 8       | 5 016 ± 6 446                                           | 0       | -                                                        | 5 016 ± 8 646                                               | 131 ± 1 399                                                   |
| Tool handles              | 13      | 290 ± 529                                               | 25      | 5 591 ± 6 760                                           | 0       | -                                                        | 2 058 ± 4 316                                               | 161 ± 1 270                                                   |
| Thatch grass              | 69      | 2 749 ± 5 128                                           | 40      | 13 044 ± 17 847                                         | 38      | 1 017 ± 1 506                                          | 5 510 ± 11 536                                               | 2 779 ± 8 614                                                 |
| Weaving reeds             | 34      | 862 ± 1 107                                             | 40      | 991 ± 1 388                                             | 0       | -                                                        | 926 ± 1 237                                                | 258 ± 768                                                    |
| Wild fruits               | 77      | 374 ± 437                                               | 68      | 130 ± 154                                               | 0       | -                                                        | 252 ± 347                                                  | 118 ± 268                                                     |
| Wild honey                | 8       | 850 ± 1 227                                            | 10      | 812 ± 1 130                                             | 0       | -                                                        | 829 ± 1 068                                                 | 50 ± 316                                                     |
| Wild herbs                | 40      | 240 ± 130                                               | 25      | 209 ± 128                                               | 0       | -                                                        | 228 ± 128                                                  | 47 ± 109                                                     |

1. Av. direct-use value per user HH (R/yr): a) Njela: 39 843±38 802; b) Gogogo: 16 796±19 702; c) Ludaka: 1 573±2 894
2. Av. direct-use value across all HH (R/yr): a) Njela: 39 843±38 802; b) Gogogo: 15 956±19 545; c) Ludaka: 983±2 398
Table 3. Focus group ranking (in descending order; 1 = highest) of the frequency and amount of PES collected around Njela and Gogogo.

| Rank | Njela terrestrial | Njela marine | Gogogo |
|------|-------------------|--------------|--------|
|      | Collection frequency | Crayfish | Fuelwood |      |
| 1    | Fuelwood | Crayfish | Fuelwood |      |
| 2    | Medicinal plants | Mussel | Medicinal plants |      |
| 3    | Wild fruit and wild herbs | Fish | Wild herbs |      |
| 4    | Walking/fighting/stirring sticks | Red bait | Bushmeat |      |
| 5    | Thatch | Limpets | Wild fruit |      |
| 6    | Poles (fencing) | Oysters | Thatch |      |
| 7    | Bushmeat | Octopus | Walking/fighting/stirring sticks |      |
| 8    | Wild honey | Palm fronds | Wild honey |      |
| 9    |        |        | Poles (fencing) |      |
| 10   |        |        |        |      |

Amounts collected

| Rank | Njela terrestrial | Njela marine | Gogogo |
|------|-------------------|--------------|--------|
| 1    | Fuelwood | Crayfish | Fuelwood |      |
| 2    | Poles (fencing) | Crayfish | Poles (fencing, kraal) |      |
| 3    | Thatch | Fish | Thatch |      |
| 4    | Wild herbs | Oysters | Medicinal plants |      |
| 5    | Walking/fighting/stirring sticks | Red bait | Walking/fighting/stirring sticks |      |
| 6    | Medicinal plants | Limpets | Wild fruit |      |
| 7    | Wild honey | Octopus | Wild honey |      |
| 8    | Bushmeat | Palm fronds | Wild herbs |      |
| 9    |        |        | Medicinal plants |      |
| 10   |        |        |        |      |

thatch grass as roofing material and >35 indigenous poles per household per annum (Table 3). Indigenous poles collected from local forests were primarily used for fencing and livestock enclosures (kraals), while poles for the construction of permanent structures in the homestead were purchased from government plantations. Although the collection of these resources was largely to meet direct household needs, some households also reported collecting surplus for local trade. For a few households, trade only occurred on an ad hoc basis or on demand to supplement income. However, in other cases trade was well developed in that a large proportion of households were selling, or a specific household regularly sold a specific resource. In these cases, trade often represented the primary cash generating livelihood activity.

The collection of medicinal plants was observed but not quantified. Focus group participants explained that small quantities of medicinal plants were collected when needed. Although wild fruit was reported to be collected opportunistically by women undertaking household chores, such as collecting fuelwood, household survey questions surrounding the quantification of wild fruits were always re-directed by the head of the household to children as they were considered the primary consumers. A few handfuls of various wild fruit, including intongwane (Englerophytum natalense), ingwenya (Harpephyllum caffrum), mbombo (Caesalpinia decapetala) and amaqaqane (Rubus spp.) were collected in season en route to and from school. However, they were collected in small quantities in comparison to other PES such as fuelwood and poles. Trendline and timeline exercises indicated that there was little change in use or harvest of PES over time.

All indigenous forests and communal lands were under customary tenure. This allowed residents to freely collect local PES, but the collection of resources in spaces outside of their village required a small fee payable to the traditional leadership of the area. Traditional leadership were identified in FGDs as responsible for the management of natural resources.

Proportion of households in Njela using a range of aquatic PES

The collection of marine provisioning services in Njela was pervasive, with 83% of respondents harvesting at least one marine resource in the last year. Fishing and related activities were a small-scale, artisanal operation for substance use or local-level trade. Fishing and harvesting activities took place within a 1.4 km radius from the village, in most cases using simple, traditional fishing gear. Some residents had access to professional crayfishing gear which was provided by a local businessman who purchased the catch for sale in the nearby town. Fishers did not have access to any vessel and were limited to fishing along the shore or estuary. Artisanal fishing was dominated by men, while women gleaned the intertidal zone for edible shellfish and other marine products. According to villagers, marine systems were an open access regime without regulations other than for crayfish (season, size and quantity of crayfish per day; which were infrequently monitored), anyone could harvest marine resources whenever they wanted.

Crayfish, mussels and fish were ranked as the most frequently collected aquatic products as well as being collected in the largest quantities (Table 3). This accorded with household surveys which highlighted that 71% of households harvested an average of six crayfish three times a week and 12 litres of mussels twice a week. Forty-five percent of households caught an average of three fish, twice a week. Other marine
resources such as red bait, limpets and octopus were collected by >50% of respondents as bait for fishing and crayfish activities, while oysters were collected by 20% of households primarily for sale at privately owned holiday cottages nearby.

**Gross direct-use and traded values of PES to households**

In this study, direct-use and trade values are reflected as a combined figure. There was a significant difference in the yearly PES values amongst user households between villages (H = 62.8, p < 0.001), with the highest value in Njela (R39 843 ± 38 802) and less than half that in Gogogo (R16 796 ± 19 702) (Table 2). The greatest significant difference was found between Njela and Ludaka, which had a direct-use value of R1 573 ± 2 894 per annum. This was a reflection of the contribution of marine resources, which yielded a mean annual value of R30 994 ± 33 646 to Njela households (Table 4), representing 60 ± 33% of the total average, annual value of all PES in Njela. When extrapolated across the whole village, consisting of 85 households (Statistics South Africa, 2011), the estimated total value of marine resources for the entire village was R3.18 million per year.

Mussels and fish were the highest contributors to the total value of marine products in Njela (mean R14 669 ± 20 485 and R14 185 ± 13 462 per user household, respectively). These were primarily for domestic consumption within the household, while crayfish, which contributed an average of R13 351 ± 13 077 per year in user households (Table 4), were a highly traded marine resource.

A few terrestrial PES products also contributed disproportionately to the total PES value per household. For example, fuelwood, thatch grass and indigenous poles, represented 78% of the total terrestrial PES value amongst all households (user and non-users) in Njela (Table 5). Corresponding cumulative figures contributed 82% in Gogogo. Although widely used in each village, the remaining PES represented very low-income contributions to the household. This may be due to infrequency of collection, and/or low local prices.

The mean direct-use value of the three highest contributing terrestrial PES, fuelwood, thatch grass and bushmeat, were more than double the value in Gogogo than in Njela (Table 2). This was likely a reflection of both unit price and quantity consumed, as for some PES the range in prices between villages was larger than the quantities consumed and vice versa. For example, the average price of a fuelwood load in Njela was R27 in comparison to R50 a load in Gogogo. In contrast, thatch bundle prices were similar but the average number of bundles collected differed at 101 and 387 bundles per household per annum in Njela and Gogogo,

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**Table 4.** The prevalence of use (% of households) and the average annual value (R) of marine provisioning services to rural households (self-collected use only) in Njela.

| Resource     | Proportion (%) of HH | Av. annual direct-use and traded value per user HH (R/yr) | Av. annual direct-use and traded value across all HH (R/yr) |
|--------------|----------------------|----------------------------------------------------------|----------------------------------------------------------|
| Crayfish     | 71                   | 13 351 ± 13 077                                          | 9 536 ± 12 654                                           |
| Fish         | 45                   | 14 185 ± 13 462                                          | 6 485 ± 11 695                                           |
| Limpets      | 54                   | 1 005 ± 1 190                                            | 443 ± 965                                                |
| Mussels      | 71                   | 14 669 ± 20 485                                          | 11 113 ± 18 854                                          |
| Red bait     | 51                   | 3 261 ± 3 781                                            | 1 677 ± 3 212                                            |
| Octopus      | 57                   | 1 347 ± 1 526                                            | 884 ± 1 415                                              |
| Oysters      | 20                   | 7 834 ± 10 223                                           | 1 662 ± 6 030                                            |

Av. direct-use value per: a) user HH (R/yr) 37 407±33 559  
  b) all HH (R/yr): 30 994±33 646

**Table 5.** Average proportional contribution of PES to overall terrestrial PES value amongst all households (i.e. users and non-users) in Njela and Gogogo.

| PES              | Njela | Gogogo | Combined |
|------------------|-------|--------|----------|
| Fuelwood         | 49 ± 28 | 56 ± 38 | 52 ± 33  |
| Thatch grass     | 18 ± 20 | 22 ± 34 | 20 ± 28  |
| Poles (fence)    | 11 ± 20 | 4 ± 6   | 7 ± 15   |
| Weaving reeds    | 5 ± 8   | 5 ± 17  | 5 ± 13   |
| Wild fruit       | 6 ± 12  | 2 ± 3   | 4 ± 9    |
| Walking stick    | 1 ± 6   | 3 ± 9   | 2 ± 8    |
| Bushmeat         | 2 ± 9   | 1 ± 4   | 1 ± 7    |
| Fighting stick   | 0 ± 0   | 2 ± 10  | 1 ± 7    |
| Palm fronds      | 2 ± 9   | 0 ± 1   | 1 ± 6    |
| Wild herbs       | 1 ± 3   | 1 ± 1   | 1 ± 2    |
| Grass hand-brushes| 1 ± 1  | 1 ± 3   | 1 ± 2    |
| Stirring stick   | 0 ± 0   | 1 ± 6   | 1 ± 5    |
| Wild honey       | 1 ± 5   | 0 ± 1   | 1 ± 4    |
| Tool handles     | 0 ± 0   | 1 ± 4   | 1 ± 9    |
| Mushrooms        | 0 ± 1   | 1 ± 3   | 1 ± 2    |
respectively. The majority of other PES provided similar yearly income to households in Njela and Gogogo.

The range in gross, annual, direct-use values between user households within the sampled communities was large, from less than R60 per household per annum to almost R143 000. Households that harvested a wide number of PES, for household consumption and/or trade, were among those with the largest average annual economic values (Njela: $R^2 = 0.41$, $F = 23.3$, $p < 0.001$; Gogogo: $R^2 = 0.43$, $F = 29.1$, $p < 0.001$) (Figure 2). For example, one household in Njela harvested 15 PES (terrestrial and aquatic) with an approximate annual value of R142 922. Over 60% of this value was represented by marine PES such as crayfish (which alone was valued at R48 372 per annum), fish and mussels. Amongst terrestrial PES, poles dominated and contributed a cash equivalent of R37 056 through the collection of 1 500 poles per year valued at R25 each. In this household of eight persons the trade of crayfish and poles, represented the most important source of household income. Another household in Gogogo frequently harvested 14 types of PES. In this household, collection of wood for walking, stirring and fighting sticks contributed R28 885 alone, followed by the harvest of wood for tool handles at R11 400 and thatch grass at R16 388 per annum. In this household, trade of various PES was identified as the primary source of income. The head of the household was responsible for the harvest, craft and sale of the various sticks, while his wife was responsible for thatch grass collection. Thatch grass was stored in a separate structure in the homestead, protected against the elements, and sold throughout the course of the year.

Conversely, households that collected few or infrequently garnered little economic value from them. For example, one household in Gogogo, with a PES value of R60 per annum, collected a few handfuls of wild fruit, or made a stirring stick and two grass brushes per annum. This household was heavily dependent on social grants as ill health constrained their ability to collect PES.

Discussion

The study sought to determine the extent of use and reliance of rural households on locally available PES along a gradient of decreasing landscape heterogeneity. Our original hypothesis was supported as evidenced by marked differences in the diversity and value of PES used along the gradient, being greatest in the most heterogeneous site (Njela) and lowest in the least heterogeneous site (Ludaka). Locally harvested PES played a significant role in rural households in Njela and Gogogo, but only to a limited extent in Ludaka. This was illustrated by the pervasive use of a wide range of PES from communal lands and aquatic environments to fulfil several livelihood requirements, particularly direct household consumption and trade to generate cash income. This significant use and high value of PES is a common feature amongst rural households and is highlighted by numerous other studies in the Eastern Cape (Shackleton et al. 2002a, 2007b; Cocks and Wiersum 2003; Maroyi 2022), South Africa (Dovie et al. 2005, Thondhlana et al. 2012; Mugido and Shackleton 2017) and further abroad (Hogarth et al. 2013; Kalaba et al. 2013; Angelsen et al. 2014). Most households in each village harvested at least one local PES, although there was variation in the average number of resources harvested per household in each village. A greater number of PES were harvested by residents in Njela, who had proximate access to a wider number of landscapes, including aquatic estuarine ecosystems, than residents in the two inland villages.

Figure 2. Regression indicating the number of PES collected and corresponding direct-use and trade value (Rand) per household per annum in Njela (A), Gogogo (B). (US$1 = R15 at time of data collection).
Although we have interpreted the primary differences to be a result of the local landscape diversity the reality is likely to be more complex. For example, although households in Njela used marine resources extensively, the high mean value per household was skewed by the significant sale of marine resources to a third-party buyer. The presence of the third-party buyer is itself a consequence of the high market value more widely of marine resources that makes it cost-effective for them to travel to Njela. Thus, the high value of PES to Njela households is not due solely to the habitat heterogeneity available to them, but also a market opportunity. A similar observation was made by Hadju et al. (2020) at Cutwini in Pondoiland (approx. 80 km north) where the relative importance of fish and crayfish had increased by over 200% in 14 years due to the link created with an external market, whilst in Manteku the value was multiplied through sales of fish to tourists. Indeed, the results indicate that the generally positive relationship between number of PES used and household income can be skewed though trade in one or more PES, as was particularly noticeable in Njela. Ruiz-Pérez et al. (2004) argue that it is the trade in high-value, wild-harvested PES, as opposed to consumptive use, that allows some households to earn sufficient income to alleviate poverty. However, Belcher and Schreckenberg (2007) argue that trade alone is not sufficient, and a number of other context enablers need to be in place, such as appropriate policies and governance institutions, an equitable value chain and local value addition.

Most households (83%) in Njela made use of PES from aquatic ecosystems in one way or another, with crayfish and mussels as the most widely harvested resources. This is comparable to Shackleton et al. (2007b) who reported widespread harvest (>85% of households) of marine resources, primarily mussels and fish, in Ntubeni, a coastal village approximately 85 km south of Njela. Apart from marine resources only immediately available to residents in Njela, patterns of resource use were similar in Njela and Gogogo. While in Ludaka, use of PES was scant owing to its location and the distance from wooded areas and marine habitats. In Njela and Gogogo, fuelwood and wild fruits were among the most widely harvested terrestrial PES. Widespread use of these resources is echoed in other studies in South Africa, for example: Twine et al. (2003) reported pervasive use of fuelwood (97%) and wild fruits (95%) across three villages in Limpopo and Shackleton et al. (2002a) found a mean of 99% and 92% of households using fuelwood and wild fruits, respectively, in three villages in the Kat River, Eastern Cape. Similar proportions of fuelwood users were mirrored elsewhere in Africa, with 89% of rural households in villages in eastern Ethiopia (Asfaw et al. 2013). However, across these studies and elsewhere (e.g. Shackleton and Shackleton 2006; Shackleton et al., 2002b; Paunggarten and Shackleton 2009), a higher proportion of households (>90%) harvested an abundance of other PES such as wild herbs, wood for wooden utensils, and grass for hand brushes. For example, Maroyi (2022) reported the use of 163 plant species across five sites in the Eastern Cape. In comparison, less than half of the households in this study harvested these resources. Differences in grass collection for hand brushes may be related to several individuals in each village who made and sold grass hand brushes, thereby making it unnecessary for most households to collect grass and make their own. Indeed, grass hand brushes are amongst the most extensively traded natural product in South Africa (Shackleton and Campbell 2007; Mjoli and Shackleton 2015). Alternatively, fewer households involved in the harvest or construction of grass hand brushes or wooden utensils may be an indication of product specialisation, as households who indicated use or collection of these products usually collected the raw materials in large quantities. This is corroborated by Wollenberg and Nawir (2005, p. 319) who, in investigating resin production in agroforests in Pesisir Sumatra, found that certain households developed their entire livelihood around trading an individual PES. This was despite the value of the product appearing low, as households compensate for low unit value by increasing the quantity sold and benefitting from economies of scale.

The emergence of local and regional markets and access to household items that local communities would have formally made for themselves is explored by Shackleton et al. (2007c) and Hadju et al. (2020) who relate it to growing social and economic connectivity and modernisation, which has resulted in an increasing need for cash. This is not the only sort of change that many rural communities in the region and globally are experiencing. Tourism developments can be a driver of social, cultural and economic change in rural livelihoods, as observed in our study in the emergence of a market for marine PES to supply tourist demand. Tourism developments can also change the nature of landscapes and access to them or some services from them (Iacopino et al. 2022). At local scales landscape heterogeneity is not static, but changes in response to local and wider-scale drivers, such as infrastructure developments, invasive species, land degradation and economic opportunities, to name a few. Consequently, the mix of PES available and used and their contribution to household income is also dynamic. For example, the widespread deagrarianisation in the Eastern
Cape province (Shackleton et al. 2019), where our study villages are located, is resulting in invasion of the abandoned fields by a suite of species that provide different PES than the previous agroecological mosaic (Njwaxu and Shackleton 2019), including invasive alien species in some areas that limit other PES (Jevon and Shackleton 2015). Elsewhere in the province, Falayi et al. (2019) describe how the invasion of abandoned fields by useful firewood species has catalysed the emergence of local trader in firewood (because of increased resource abundance).

Although many previous studies have shown the pervasive use of wild herbs in South Africa and neighbouring countries (e.g. Shackleton 2003; Maroyi, 2011) it is likely that in this study, wild herbs were more readily and/or frequently harvested from home gardens than from nearby ‘natural’ habitats. It is also likely that the use of some products, like wooden utensils, that have traditionally played a key role in livelihoods are diminishing and are being replaced by synthetic modern goods (plastic household utensils, furniture, etc.) (Shackleton et al. 2011b) and that the interest, knowledge and time required to make them is diminishing (De Vletter 2001; Mutua et al. 2004). Conversely, despite broader shifts towards electricity as an energy source and alternative construction materials, other PES, such as fuelwood and construction materials (indigenous poles and thatch), remained central in the livelihoods of the respondents, with approximately two-thirds of households in Njela and Gogogo harvesting these PES.

The results indicate that the gross annual value of PES consumed and traded by households varied with changing proximity to different landscapes. Similarly, households harvesting a greater number of PES generally benefited from a greater direct-use and trade value. On average, PES provided a gross, annual direct-use and trade income of R39 843 ± 38 808 to all households (user and non-user) in Njela, and lower amounts in Gogogo (R15 956 ± 19 543) and Ludaka (R983 ± 2 398). The values calculated for Njela and Gogogo were higher than other areas in the Eastern Cape province with access to similar PES as reported by Shackleton et al. (2007b) amounting to R24 066 and R9 181 in two coastal villages in the Transkei or savanna biomes reported by Shackleton et al. (2002a) in three villages in the Kat River which amounted to R5 987, R3 899, and R3 809. However, they are on a par with global averages of environmental income (natural forest and non-forest environmental) at R8 733 or the African average at R5 229 per adult equivalent per annum (Angelsen et al. 2014). Values in Njela were 78% higher than global figures. The incomes from PES in Njela and Gogogo were also higher than those for arable agriculture (Herd-Hoare and Shackleton 2020a) and also livestock production (Herd-Hoare and Shackleton 2020b) further demonstrating their significance in these communities.

A few possible explanations for higher values in this study exist. First, most studies that report on the value of natural resources consider the direct-use values to household consumption or trade, whereas this study reports a cumulative figure of both direct-use and trade value. Naturally, this figure would be higher but in most cases PES were consumed directly and only a few households were involved in trade which usually occurred on an ad hoc basis. Secondly, the high values in Njela are related to the high contribution (60% of total PES value) of aquatic products, as a consequence of the high proportion of households (71%) involved in frequent crayfish harvesting. Local crayfish divers in Njela were the primary suppliers to a third-party company who distributed crayfish to restaurants in a nearby city. Divers described how they were heavily dependent on this trade for cash income to purchase daily necessities. Other marine products such as mussels, a common staple food, amounted to R11 113 ± 18 854 per annum amongst all households. Few other PES studies in South Africa have been conducted at a coastal site and hence in areas where marine resources are used. This requires more studies to take place in coastal areas. This high variation between sites and studies emphasises the need for local-level studies rather than value transfer from previous work.

In contrast, Ludaka had limited access to PES due to the low landscape heterogeneity of the area. Residents in Ludaka, with access to local grass species for grass hand-brush construction and thatch grass only, are potentially impoverished in not being able to enjoy the PES available in other villages, except through purchase which is therefore likely to reduce cash resources. In the same way, if the abundance or supply of PES in Njela and Gogogo is jeopardised, it could have measurable repercussions on the well-being of residents in these villages.

The three greatest terrestrial contributors to the total direct-use and trade values in Njela and Gogogo were fuelwood (52%), thatch grass (20%) and indigenous poles (7%). Together these resources accounted for 78% of the gross annual, direct-use and trade value in Njela and 82% of the value in Gogogo. These high proportional contributions are typical of previous studies both locally (Dovie et al. 2002; Shackleton and Shackleton 2004; Paumgarten and Shackleton 2009) and further afield (Ngwenya and Hassan 2005; Babulo et al. 2009). The continued use of fuelwood even though electricity is available is a function of the increased supply of wood through plant succession on old fields (Falayi et al. 2019) and the prohibitive costs of electrical appliances.

Relating the annual economic value of PES used in Njela and Gogogo to other means of livelihood income provides deeper insight into their inherent value. One
useful comparison is with other income sources in the household. For example, in many cases the state old-age pension forms the backbone of the rural household cash economy across South Africa, making a major contribution to household cash income (Ranchhod 2009; Hadju et al. 2020). In this way, comparison of PES value to state pension values provides a useful yardstick. In Njela and Gogogo, households received a mean of 0.4 pensions, amounting to R640 per month or R7 680 per annum (Herd-Hoare 2018). This represents a mere 20% of the annual total mean direct-use and trade value of PES in Njela and 50% in Gogogo.

Another useful comparison can be made with household expenditure on important goods and services. Maize meal is a staple food in each village, with households purchasing large bags every month. A 50 kg bag of maize meal cost R332 in 2016 and would last the average household almost one month. This meant each household spent an average R3 984 on maize meal a year, which is 10% of the PES cash equivalent in Njela and 25% in Gogogo.

**Conclusion**

There is little doubt that PES play a pivotal role in the lives of communities in this study, contributing to their energy, nutritional, utilitarian, medicinal and cash income needs. The use of locally harvest PES was pervasive in Njela and Gogogo, the residents of which had access to more heterogeneous landscapes in comparison to Ludaka, which did not and where limited PES were collected. The value of PES was higher than previous studies in South Africa, and almost double the value in Njela than in Gogogo. These high economic values in both villages reflect high reliance on local PES due to poverty, remoteness from market centres and proximity to key PES rich landscapes such as marine ecosystems. Fuelwood and wild fruits were the most widely harvested terrestrial PES, with the highest proportional economic contributions from fuelwood, indigenous poles and thatch grass. This is noteworthy, considering all villages have electricity and there is a trend towards use of alternative construction materials such as brick and corrugated iron. Given the socio-economic context of the villages and the significant cash saving function, it is unlikely that the use of PES will diminish in the near term.

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