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Understanding Tagasaste Integration in South African Farming Systems: Farmer Experiences and Implementation Challenges

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ABSTRACT

*Tagasaste is a multipurpose leguminous shrub known for its nitrogen-fixing ability, high-protein forage and adaptability to poor soils and dry conditions. While interest in tagasaste has persisted for over four decades, widespread adoption remains limited due to propagation difficulties, lack of region-specific information and limited extension support. This study investigates the potential role of tagasaste (*Chamaecytisus palmensis*) in supporting climate-smart agriculture (CSA) in South Africa. A mixed-methods approach was used to integrate qualitative and quantitative data collected via an online survey, farmer feedback, and secondary literature. Thirty-six farmers participated in the survey, sharing experiences related to tagasaste adoption, establishment challenges and perceived benefits. Survey results showed strong farmer interest in sustainable agriculture (~95%) and a perceived role for tagasaste in supporting fodder production (~95%), soil rehabilitation (~72%) and ecosystem services (~78%). Secondary data confirm its capacity for carbon sequestration and adaptive resilience. The study concludes that, with appropriate management practices—such as seed scarification, planting in well-drained soils at the correct depth, weed suppression during establishment, and early protection from grazing—alongside regionally adapted propagation techniques and farmer support, tagasaste could be a valuable component of diversified farming systems. It offers potential contributions to both climate change mitigation and adaptation while improving productivity and ecosystem services. Recommendations include site-specific trials,*

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farmer training, and the development of a practical, locally tailored guide that consolidates regionally relevant knowledge on the establishment, maintenance, and use of tagasaste. Best-practice management approaches could improve establishment rates, increase yields and build long-term resilience of farming systems under climate stress.

Keywords: Fodder Crops, Sustainable Agriculture, Extension Services, Rural Livelihoods, Adaptation, Mitigation.

1. INTRODUCTION

1.1. Background

Land provides essential resources, including food, clean water, timber, biodiversity, and ecosystem services, necessary for human survival. Ecosystem functions include climate regulation, flood prevention, decomposition of organic waste, air and water purification, carbon sequestration, biodiversity support, and crop pollination (Rockström *et al*., 2023). Human activity has altered Earth's carbon, water, and nutrient cycles—the results of which are referred to as anthropogenic climate change (Zalasiewicz *et al*., 2002; Rockström *et al*., 2009). Conventional intensive agriculture—particularly monocultures—contributes to soil degradation through chemical pollution, salinisation, acidification and inefficient irrigation (IPCC, 2023). Globally, 12 million hectares of land are degraded annually due to human activity (UNCCD, 2017). This underscores the need for sustainable agricultural solutions, particularly in developing regions.

These ongoing impacts risk destabilising environmental systems and negatively affecting food security (Rockström *et al*., 2009; Bradshaw *et al*., 2021). Food security is influenced by population growth, resource availability and ecosystem health (Yunusa *et al*., 2018). Frameworks such as the Planetary Boundaries (Steffen *et al*., 2015), Doughnut Economics (Raworth, 2017) and the Sustainable Development Goals (SDGs) emphasise balancing human well-being with ecological limits. These frameworks define Earth system thresholds, safe social and ecological spaces and global targets for sustainable development. In the South African context, these approaches reinforce the need for agricultural systems that respect ecological limits while addressing poverty, inequality and food insecurity (Mnkeni *et al*., 2019; Montmasson-Clair & Zwane, 2016). Climate-smart agriculture (CSA) offers a practical strategy by integrating mitigation, adaptation and productivity goals. CSA promotes resource-efficient practices, supports ecosystem services and increases resilience to climate variability. Its adoption is especially relevant for smallholder and resource-constrained farmers facing intersecting vulnerabilities (Makate *et al*., 2016).

The leguminous fodder shrub tagasaste (*Chamaecytisus palmensis*) aligns with the principles of CSA through its potential contributions to climate change mitigation, adaptation and improved productivity (Dawson *et al*., 2014; Orwa *et al*., 2009). Fodder trees like tagasaste are used throughout the Global South for multiple purposes, including mulch, green manure, erosion control, and as living fences. Their low input requirements suit systems aiming to reduce dependence on external inputs (Wambugu *et al*., 2011). Tagasaste tolerates varied soil and climate conditions, persists in nutrient-poor or acidic soils, and can rehabilitate degraded land and improve forage availability in arid and semi-arid zones (Dawson *et al*., 2009).

1.2. Problem and Rationale

Although tagasaste was introduced to South Africa over a century ago (Francisco-Ortega *et al*., 1991), its adoption remains limited. Despite its multipurpose potential, the species is underutilised in sustainable agriculture, and there is little local documentation of current use or farmer experiences.

Perennial legumes and agroforestry systems offer pathways to intensify agriculture, mitigate climate impacts and improve rural livelihoods (Dawson *et al*., 2014; Adams *et al*., 2010). Legumes support nitrogen fixation, increasing soil fertility and reducing dependence on synthetic fertilisers, thereby lowering greenhouse gas (GHG) emissions (Wambugu *et al*., 2011; Li *et al*., 2009; Zhu *et al*., 2019). Tagasaste provides multiple benefits, including livestock nutrition, soil rehabilitation and carbon sequestration (Dawson *et al*., 2014; Orwa *et al*., 2009). However, limited empirical research exists on tagasaste in the South African context, particularly regarding farmer-led practices, site-specific establishment challenges, and its role in climate-smart agriculture.

1.3. Aim and Objectives

The core research question is whether integrating tagasaste into agriculture can simultaneously support adaptation to climate change impacts and mitigate agricultural GHG emissions in South Africa. While uncertainties persist in land-use and ecological research, acting on the best available evidence is supported as a practical means to reduce the risk of further environmental degradation (Primack, 2014). This study aims to address that gap by assessing the agronomic potential of tagasaste and the perspectives of South African farmers on its relevance for CSA.

This study seeks to assess the potential of tagasaste as a CSA intervention in South Africa. It explores farmer perceptions, adoption trends and the challenges associated with tagasaste cultivation. The research analyses both agronomic characteristics and implementation challenges, with a focus on its role in mitigation and adaptation to climate change. Drawing from international experience, it aims to develop recommendations for agricultural extension services and policy frameworks to support its integration into South African farming systems. Long-term field trials, broader economic assessments and analysis of gender and cultural dynamics fall outside the scope of this study.

2. MATERIALS AND METHODS

2.1. Methodology

A sequential mixed methods design (Ahmad *et al*., 2019; Fetters *et al*., 2022) was used to evaluate tagasaste's potential for climate change mitigation and adaptation in South African farming systems, using data from i) a targeted online survey distributed via agricultural networks and social media to farmers with prior experience or interest in tagasaste; ii) informal discussions with farmers (*pers. comm.*), conducted via email and WhatsApp, which emerged from the lead author's role as a consultant and tagasaste grower, providing context-specific insights into cultivation challenges;; iii) and secondary literature, including peer-reviewed articles, technical reports and practitioner resources related to tagasaste.

Qualitative and quantitative methods were applied to the survey data. Open-ended questions were used to explore perceptions, motivations and practices, while closed-ended questions captured broader trends in adoption and views on climate change and sustainable agriculture (Leavy, 2023; Taherdoost, 2022). Informal discussions with experienced farmers were used to supplement the survey data, providing additional context, particularly on cultivation challenges. Secondary literature was reviewed to compare and contextualise findings.

2.2. Data Collection and Analysis

The structured online survey, distributed via social media, targeted farmers with knowledge of or interest in tagasaste. A total of 42 responses were received, of which 36 were included in the analysis. Responses from outside of South Africa were excluded to ensure contextual relevance

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to local farming systems and climate conditions. While the total population of tagasaste users is unknown due to the crop's limited uptake and lack of formal databases, the sample reflects a diverse cross-section of interest across farm types. Validity was supported through triangulation of survey data, personal communications and secondary sources, while reliability was strengthened through consistent question design and a standardised online format. Participation was voluntary, confidential, and based on informed consent via a checkbox mechanism. Informal discussions with experienced farmers provided supplementary qualitative insights, particularly related to establishment challenges. These were used to support the interpretation of the survey data. Secondary literature was studied to contextualise findings and offer comparative insights, especially given the limited uptake of tagasaste in South Africa. Studies and research on tagasaste and similar species were reviewed for relevance to CSA.

A hybrid inductive-deductive thematic approach guided the analysis (Proudfoot, 2023). Open-ended survey responses and informal feedback were reviewed to identify recurring patterns, which were grouped thematically based on common topics raised by participants. Inductive analysis of primary data identified themes related to farmer motivations, barriers and sustainability perceptions. These themes were then assessed deductively through the literature to refine and expand the findings.

3. RESULTS AND DISCUSSION

Assessing the current status of tagasaste in South Africa is important for evaluating its relevance to CSA. In settings with limited farmer access to technical and financial support (Gwiriri *et al*., 2019; Cloete *et al*., 2022), farmer perspectives are key to understanding the potential for adoption. This section draws on survey data, qualitative insights and secondary literature to examine factors influencing its adoption, utilisation and propagation.

3.1. Adoption, Utilisation and Propagation

3.1.1. Primary Data

The survey revealed diverse motivations and challenges. Respondents most commonly cited livestock fodder as their primary reason for planting tagasaste (n = 33), followed by soil rehabilitation (n = 26) and beekeeping (n = 9). Eighteen respondents used tagasaste for multiple purposes. Respondents represented a range of farming systems, including homestead operations (n = 9), intensive (n = 7), extensive (n = 7), community-based (n = 4), and small-scale operations (n = 3). Additional models included permaculture, self-sufficiency, micro-farming, hobby farming and research-driven trials. Tagasaste was predominantly discovered through written material (n = 20), peer interactions (n = 9), or longstanding familiarity. Only 13 respondents found guidance relevant to local conditions, indicating a gap in region-specific technical support.

Of 25 farmers who attempted establishment, four reported success without difficulty, one described a "relatively good" success rate, and 12 found it difficult to establish. Propagation methods included planting seedlings (n = 15), seeds (n = 13) and potted trees (n = 5), with some respondents using more than one method. One farmer reported root rot in plants grown from seed and seedlings. Another who used seed observed partial germination and linked the results to soil quality. One noted difficulty establishing seedlings after reading that watering was unnecessary, while another who watered seedlings for two years experienced better success, though later reported 10% mortality of mature plants during hot Cape summers. One respondent observed leaf yellowing in one-year-old plants, which did not resolve after applying superphosphate. Three respondents noted that growth was slow to start but improved once established—two planted seed, and one used both seed and seedlings. One farmer reported early growth followed by plant loss. Three respondents experienced establishment failure due to browsing by livestock or wildlife. All five who planted potted trees experienced difficulties—one reported frost damage, another reported slow growth, and two described the establishment process as "very difficult." Only six farmers were aware of the plant's invasive potential elsewhere, though most did not view it as a local threat due to its palatability and limited natural spread.

Insights shared with the authors by farmers between 2012 and 2024 (*pers. comm.*) align with survey responses. Several reported plant mortality after initial growth, with symptoms such as leaf yellowing and premature leaf drop often followed by dieback. In most cases, seedlings had been propagated in bags and transplanted into heavy soils. Incorrect planting depth, root-bound seedlings and inadequate soil preparation were common factors. Farmers also cited issues such as waterlogging and pest damage under dry conditions—particularly from wood borer beetles (Cape Longhorn Beetle, Ceroplesis aethiops)—as reported. Additional feedback on chlorosis in clay soils, weed competition, and the impact of frost. One farmer found that while frost slowed growth, it did not cause mortality in young plants. Another achieved improved establishment after adjusting drainage, nutrients and weed control. Some farmers observed improved performance after introducing measures such as nutrient supplementation or livestock protection, while others discontinued cultivation.

3.1.2. Secondary Data

Tagasaste was first introduced to South Africa in 1879 (Fransisco-Ortega *et al*., 1991), but adoption was initially limited because farmers resisted innovation (Hutchinson, 1918). Interest increased during the 1980s and 1990s and again around 2012, but success was constrained by limited plant material availability and poor establishment outcomes (Viljoen, 1989; Smit, 1988; Fuglar, 1989; Viljoen, 1995; McVeigh, 1999; Erasmus, 2012). Similar challenges have been reported in Malawi and Ethiopia, including a lack of quality planting material and limited farmer training (FAO, 2014; Kumsa & Assefa, 2018). In contrast, large-scale adoption in Australia and New Zealand has been facilitated by innovations in direct seeding techniques and effective grazing management (Pannell & Ewing, 2006).

Effective propagation depends on soil preparation, weed control, protection from browsing and adequate early-stage management (Tudor *et al*., 2016; Lefroy *et al*., 2001). Establishment is supported by measures to prevent overgrazing and reduce weed competition during initial growth phases (Tozer *et al*., 2022; Moore *et al*., 2006).

While tagasaste has naturalised in ungrazed areas abroad (Cook *et al*., 2020), no local cases of invasiveness have been documented (NEMBA, 2020). Concerns over invasiveness in South Africa remain limited. Tagasaste has not demonstrated uncontrolled spread in local contexts, likely due to browsing pressure (Wiley, 2006; Lindeque & Rethman, 1998) and its limited uptake.

3.1.3. Discussion: Limitations and Potential for Adoption in South Africa

Survey responses and literature confirm that tagasaste's perceived value lies in its multiple uses—particularly as a fodder crop and for soil rehabilitation. However, challenges persist, including a lack of region-specific and technical knowledge and limited extension support. Adoption models in Australia and New Zealand indicate that improved outcomes in South Africa could be achieved through regionally adapted guidelines and farmer training.

Table 1 synthesises farmer feedback and literature-based recommendations, offering a framework for identifying and addressing reported establishment challenges. The potential economic and ecological co-benefits of tagasaste—including improved livestock productivity,

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reduced input costs and provision of ecosystem services—underscore its relevance to CSA. Although long-term monitoring is recommended to assess potential ecological impacts, current evidence suggests that the likelihood of widespread invasiveness under South African conditions is low and manageable.

TABLE 1: Summary of Challenges Experienced by Survey Respondents and Literature on Establishment Requirements of Tagasaste.

Problem	Propagation method	Participants comments	Possible reasons
Yellow leaves	Seedlings	Occurred at 1 year, added superphosphate, but may need something else.	Chlorosis; micro/macro nutrient deficiency; waterlogging; high temperatures; not enough water[1,3,5,6]
Temperature: too hot or too cold	Trees in pots; seedlings	Easy to establish, but died due to Highveld frost; 1 in 10 mature plants die during hot Cape summers.	Becomes dormant in extreme temperatures; young seedlings are intolerant to frost[1,3,6]
Difficult to grow from seed	Seed; seed and seedlings	Not all of the seed germinated; seedlings transplanted gently establish easily.	Seed requires scarification to germinate successfully; weed competition[1,2,3,5]
Root-rot	Seed and seedlings	Plants were about 1 to 1.5m tall when the problem began.	Susceptible to stem and root disease; intolerant to waterlogging[1,2,5]
Everything likes to eat it	Seed; seed and seedlings; trees in pots	Rabbits (hare) and duiker damaged plants; sheep broke in; baboon pulled them out.	Highly palatable[4,5,6]

Water: too little or too much	Seedlings; trees in pots	The literature says it doesn't need to be watered; needs water for the first 2 years; I probably haven't watered enough.	Requires water for establishment; intolerant to waterlogging[1,5,6]
Slow to get established	Seedlings; seed; trees in pots	I probably haven't watered enough; it took longer than expected, and once growing, it's easy to maintain.	Nutrient deficiency; not enough water; planted during the wrong season; unfavourable conditions [1,2,5]

Extrapolated and synthesised from the online survey and secondary data: [1]Assefa et al., 2012; [2]Dann et al., 2003; [3]Douglas et al., 1998; [4]Jeronimo et al., 2020; [5]Snook, 1986 & [6]Wiley, 2006 (Armstrong, 2024).

3.2. Mitigation and Adaptation Potential

3.2.1. Survey Results

Survey results showed that ~80% of respondents believe climate change presents a threat to the environment and humanity. Some noted that the primary impact would be on human systems, while others believed natural systems are more resilient. A minority expressed scepticism about climate change, attributing environmental degradation to pollution and unsustainable consumption.

Most respondents agreed that unsustainable agricultural practices can result in land degradation, reduced soil fertility, water pollution, biodiversity loss and increased carbon emissions. Approximately 95% supported adopting more sustainable farming methods. Commonly cited approaches included conservation agriculture, regenerative practices and no-till systems. Twenty-five respondents stated that tagasaste improves soil fertility, largely due to its leguminous nature. A few noted potential nutrient competition with other crops in mixed systems. Seventeen respondents reported that tagasaste has a lower water demand than fruit and nut trees once established, although others were undecided due to limited experience.

Crop and livestock selection was most often based on suitability to local conditions and profitability, with environmental considerations ranking third. Most farmers reported that consumers influence production decisions, particularly in market-driven systems. Factors influencing consumer demand included price, media and industry trends.

Twenty-two respondents indicated that tagasaste could support both mitigation and adaptation to climate change. Four believed it supports adaptation only, two cited mitigation only, two indicated neither and six did not respond. Among those who responded, tagasaste was most commonly cited as suitable for fodder, soil improvement, beekeeping and land rehabilitation.

3.2.2. Secondary Data

No South African studies have yet quantified the carbon sequestration potential of tagasaste. However, an Australian study by Wocheslánder *et al*. (2016) estimated sequestration at 9.2 Mg CO_2e ha^{-1} yr^{-1} under 37.5% canopy cover in an alley cropping system with a planting density of 550 plants per hectare. To contextualise this estimate within a South African setting, data from Mills and Cowling (2006) show that the indigenous species spekboom (*Portulacaria afra*) can sequester up to 14.9 Mg CO_2e ha^{-1} yr^{-1} under 93% canopy cover following restoration.

Mills and Cowling (2014) extrapolated their earlier findings to estimate spekboom sequestration at full (100%) canopy cover. Using the same proportional method, the potential sequestration rate for tagasaste was estimated at approximately 24.5 Mg CO_2e ha^{-1} yr^{-1} (Armstrong, 2024), relative to 15.4 Mg CO_2e ha^{-1} yr^{-1} for spekboom (Mills & Cowling, 2014). Extrapolations assumed a linear relationship between canopy cover and sequestration rates—potential non-linear effects, such as density-dependent growth limitations, resource competition or edge effects, were not accounted for. As the original studies were conducted under different climates, soil types and management systems, the comparability of results remains limited. Additionally, practical applications such as grazing or harvesting reduce effective canopy cover and planting density, resulting in sequestration rates lower than the extrapolated maxima (Gebremedhn *et al*., 2022).

An economic analysis by the EverCrop Carbon Plus project (Thomas *et al*., 2015) suggested that integrating livestock into tagasaste systems can maintain carbon benefits while improving financial returns. Additionally, tagasaste's high protein and tannin content may lower methane emissions from ruminants by improving enteric fermentation (Min *et al*., 2020; Dawson *et al*., 2014).

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Tagasaste exhibits characteristics that support resilience in water-limited environments. Its dimorphic root system allows access to both shallow and deep water sources (Lefroy *et al*., 2001). Under stress, the plant sheds leaves to reduce transpiration and performs hydraulic lift to support root function. Water use efficiency has been measured at 247 L per kg of dry matter, which compares favourably with lucerne (*Medicago sativa*), reported at 713 L per kg (Singh *et al*., 2014).

Tagasaste contributes to land rehabilitation primarily through erosion control, water and nutrient cycling and biological nitrogen fixation (Dawson, 2014). It can moderate surface temperatures and reduce heat stress in livestock by providing shade (Tozer, 2022; Edwards-Callaway *et al*., 2021). Its role as a green firebreak has been documented in Western Australia (Hèuze *et al*., 2017).

Tagasaste also offers high feed value, with crude protein content ranging from 17% to 30%, making it a valuable forage for livestock (Orwa *et al*., 2009). Tagasaste is well accepted by livestock and does not cause bloat (Wiley, 2006; Jeronimo *et al*., 2020), a common concern with other fodder crops. These attributes enhance its utility in pasture-based systems aiming to improve productivity while maintaining animal health.

3.2.3. Discussion: Integrated Potential for CSA

Climate interventions that address both mitigation and adaptation are more effective than those focused on a single objective (Locatelli *et al*., 2015). Practices such as agroforestry, silvopasture, and rotational grazing using fodder shrubs can improve both productivity and ecosystem function (Mbow *et al*., 2014; Tiefenbacher *et al*., 2021). In this context, tagasaste may offer advantages in managed fodder systems due to its high feed value, environmental adaptability and mitigation potential. Table 2 summarises the potential mitigation and adaptation benefits of tagasaste.

TABLE 2: Potential Mitigation and Adaptation Benefits of Tagasaste

Tagasaste uses	Mitigation	Adaptation
Livestock fodder	Direct grazing reduces the need for transporting feed from elsewhere	Food security, enhanced livestock well-being, increased production, and reduced land use change

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Bee keeping	Enhanced above-ground carbon stocks - plants not pruned/ grazed to allow flowering	Increased biodiversity and enhanced pollination of food crops
Land rehabilitation	Enhanced carbon sequestration, reduced albedo, and repair ecosystem services	Can be designed to provide shade and windbreaks, 'green' firebreaks, and enhanced ecosystem resilience
Soil improvement	Reduced GHG emissions due to decreased fertiliser use	Improve naturally poor soils or damaged soils to increase productivity
Landscaping	Carbon sequestration, designed to repair ecosystem services, including biodiversity	Design to provide shade and windbreaks, 'green' firebreaks
Pelleting (bagged feed)	Carbon sequestration, reduced GHG emissions if pelleting is achieved on-farm	Fodder banking for dry season or times of drought, enhanced food security
Carbon sequestration	Avenue to attract funding for carbon offsetting projects	Design projects to have adaptation co-benefits, such as improved livestock fodder
Windbreaks	Carbon sequestration, soil preservation	Shade, cooling of soil, wildlife corridors
Firewood	Reduction of harvesting indigenous trees for fuel	Provision of fuel for cooking where other trees are not available
Agroforestry & alleycropping	Carbon sequestration, less GHG emissions, reduced albedo, ecosystem services, including biodiversity	Agri diversification can reduce risks caused by climate change, food security
Permaculture and food forests	Carbon sequestration, less GHG emissions, reduced albedo, ecosystem services, including biodiversity	Agri diversification can reduce risks caused by climate change, food security

Mulching	Increased soil carbon stocks, reduced albedo	Improved soil biology, cooling of soil, weed suppression, enhanced water retention
"Green" firebreaks	Carbon sequestration, soil preservation	Help prevent wildfires, shade, cooling of soil, and wildlife corridors

Data extrapolated and synthesised from: Cusworth et al., 2022; Nayak et al., 2022; Cardinael et al., 2021; EdwardsCallaway et al., 2021; Climate Positive Design, 2020; Ramankutty et al., 2018; Myers et al., 2017; Locatelli et al., 2015; Dawson et al., 2014; Mbow et al., 2014; Wambugu et al., 2011; Brussaard et al., 2010; and Orwa et al., 2009 (Armstrong, 2024).

4. CONCLUSION AND RECOMMENDATIONS

This study evaluated the potential of tagasaste to support mitigation and adaptation strategies in South Africa. Drawing on the Planetary Boundaries Framework, Doughnut Economics and the SDGs, the research explored how the use of tagasaste within CSA systems can improve environmental resilience and food security within ecological limits.

Although interest in tagasaste has persisted for over four decades, adoption remains limited due to technical barriers and establishment challenges. Survey responses indicate that farmers are actively seeking alternatives to address soil degradation and climate variability. Tagasaste is well suited to rehabilitating degraded land, increasing fodder availability and reducing input dependency—particularly in arid and semi-arid zones.

Its capacity for carbon sequestration suggests it could be included in carbon offset projects. High tannin and protein content may reduce methane emissions from livestock, while its adaptability, water-use efficiency, and ability to maintain feed supply under dry conditions enhance its role in adaptation strategies. These attributes contribute to greater farm resilience and reduced economic risk, especially among resource-constrained smallholders.

An important aspect of further research will be to determine localised carbon sequestration rates and agronomic performance under varying environmental and management conditions. This includes evaluating the role of site-adapted seed and genomic traits in improving productivity. Structured trials and pilot plantings will be essential to inform best management practices. A locally tailored handbook could assist farmers with propagation, site selection, system integration and the adoption of innovations—particularly in contexts where openness to new approaches varies. Regulatory guidance from DFFE and DoA, under the Conservation of Agricultural Resources Act (Act 43 of 1983), could enable integration into South African farming systems.

Aligned with CSA principles, tagasaste may offer a cost-effective option to improve productivity and environmental outcomes, particularly in areas where soil degradation and water scarcity are limiting factors. Its application on marginal land and its potential to attract climate finance suggest it is relevant to integrated sustainability outcomes in South Africa, though further evidence is needed to support widespread implementation.

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