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Unlocking and securing ecological infrastructure investments: The needs and willingness to invest and institutional support mechanisms used

Ecological infrastructure (EI) is a natural and near-natural functioning ecosystem that delivers a range of essential services to humankind. Examples include mountain catchments, wetlands, coastal dunes, and riparian corridors. In a world where EI is underinvested, rapid degradation and threats such as unsustainable veld-fire regimes, droughts, climate change, and invasive alien plants persist in dominating the ecological landscape. In South Africa, there are government programmes that encourage the restoration, rehabilitation and protection of EI. However, inadequate funding allocations constrain scaling-up and thus necessitate the unlocking of public and private sector investments to augment resources for ecosystem-based management interventions. A systematic literature review was conducted at a global scale to (1) understand the drivers behind EI investments, (2) understand the willingness and desire of private landowners and land users to participate and contribute to EI investments and (3) identify institutional support mechanisms used to encourage investments. Results suggest that the need to invest is driven by growing degradation of EI and the urgency to meet environmental sustainability goals. The willingness to invest is stimulated by the use of economic-based policies and compensatory mechanisms. Public–private partnerships, public policy, and market-based conservation instruments are institutional arrangements executed to protect EI. These include processes and systems used by the institutions to legislate and manage interventions towards fulfilling the conservation objective. Our review contributes to the EI investment research agenda by recommending coordinated efforts to encourage EI investment from both public and private partners. These measures will help to secure financial resources and mobilise investments beyond monetary terms by coordinating planning and developing capacity and reform policies.

Significance:

- Reviewing international experiences on ecological infrastructure investments will help to inform the Natural Resources Management programmes' efforts to upscale the investments essential to conserve natural ecosystems. The lessons from the systematic review will further reveal other related natural ecosystem investment processes from which to learn. Therefore, gaining a global understanding of these lessons provides evidence-based advice for policy development and decision-making processes which seek to protect natural ecosystems for present and future generations.

Introduction

South Africa is biologically diverse^{1,2} with a wide range of important ecosystems that deliver essential services to support humankind. Concerns about the rapid rate of environmental degradation and potential effects on society have triggered a need for substantial investment efforts to counteract such impacts whilst advancing sustainability and the National Development Plan agenda for South Africa.³ The South African government instituted Natural Resources Management (NRM) programmes to maintain and repair ecological infrastructure while alleviating poverty.

The term 'ecological infrastructure' (EI) refers to a natural or near-natural functioning ecosystem that delivers essential services to humankind. Examples include mountain catchments, wetlands, coastal dunes and riparian corridors.^{3,4} The ecosystem services (ES) supplied by the EI are equivalent to socio-economic services (e.g. electricity supply) which are derived from built infrastructure. The EI concept carries an economics and development argument essential to attract public attention for ES support and public and conservation policy recognition.^{5,6} The NRM programmes invest in EI rehabilitation and maintenance projects to enhance ES delivery and protect biodiversity whilst empowering underprivileged locals.^{7,8} In 2012, the demand for financing nationwide ecosystem-based management interventions was estimated to be six times more than available resources⁹ and constant and long-term support for interventions is a costly exercise.

The South African conservation legislative framework requires private landowners to be primarily responsible for the protection and conservation of EI on their private land.¹⁰ Despite this legal requirement, the contribution of private landowners towards public good investment is still insignificant.¹¹ Acknowledging this gap, a well-subsidised and theoretically reputable investment model known as agri-environment schemes^{12,13} was chosen as a comparable model to extract lessons essential for NRM guidance on policy advice and operational matters. Agri-environment schemes (AES) are major sources of nature conservation funding to respond to agricultural impacts threatening species, ecosystems and ES delivery in Europe, Australia and the USA.^{14–16} This study was motivated by the realisation that NRM's insufficient funding is linked to the reliance on one funding source and absence of investors in the EI discourse.^{11,17,18} Increasing concerns posed by unsustainable veld-fire regimes, droughts,

and floods, exacerbated by invasive alien plants, densification of woody pioneer species (bush encroachment), the loss of vegetation cover in some areas and climate change, have brought to the fore the importance of intact EI and the delivery of ES. Degradation of EI and its negative economic impacts on ES in South Africa have further stimulated interest to understand the possibilities of supplementary funding streams. This study reviews (1) the developmental needs or drivers necessitating EI investments, (2) the willingness of private landowners to participate and/or contribute towards EI maintenance and restoration measures and (3) the role of government support, policy regime and institutional arrangements to stimulate cooperation and shared responsibility for EI protection. The purpose of the study was to provide evidence-based conservation policy advice, lessons and insights to inform decision-makers, scientists, policymakers and NRM practitioners.

Methods

We chose a systematic literature review research methodology to gather scientific and non-scientific information¹⁹ to address the objectives of this study. We developed a systematic review protocol to define the review objectives, questions, criteria for source inclusion and exclusion, and keywords (see [supplementary material](#)). We created search terms to extract sources from peer-reviewed (Web of Science, Scopus, Science Direct) and grey literature databases (Google and filter bubble) published from 1970 to 2019 (Table 1). The search strategy was then broadened

to identify, evaluate and summarise all eligible sources. The search terms were entered in combination with “Agri-Environment Schemes” to retrieve AES studies relevant to the NRM investment model. Truncated words, synonyms, alternative spellings, Boolean logic, and wildcards were used in the search strings.

A pilot search was conducted prior to the definite search to improve the search strategy. To minimise non-target articles, journals of less relevance to the searched topic were excluded after scanning through their titles and abstracts. Search strings were customised based on different database specifications. The search was supplemented by a snowballing approach based on article references. Inductive (concepts emerging from the review process) and deductive (preconceived review concepts) coding methods were employed to extract thematic information from the literature. A PRISMA (preferred reporting items for systematic reviews and meta-analyses) workflow was adopted to show the selection and assessment of collected sources (Figure 1). This phase focussed on reading the article title, keywords and abstract. Subsequently, duplicates were excluded and the remaining sources were read diagonally (introduction, tables, figures, and conclusion) or in entirety depending on relevance. These sources were then imported into ATLAS.ti 8.4 (2018) for coding and qualitative analysis. The frequency of mentions from papers were scored and papers were counted as units.

Table 1: Combination of search strings used to compile literature based on three theme areas

Needs and drivers for ecological infrastructure investment	Developmental willingness and desire of private landowners to invest in the maintenance and restoration of ecological infrastructure	Assessment of institutional support and policy mechanisms used to encourage the restoration and maintenance of ecological infrastructure
“ecolog* infrastructur*” OR	“ecolog* infrastructur*” OR	“ecolog* infrastructur*” OR
“ecosystem* infrastructur*” OR	“ecosystem* infrastructur*” OR	“ecosystem* infrastructur*” OR
“environment* infrastructur*” OR	“environment* infrastructur*” OR	“environment* infrastructur*” OR
“soft infrastructur*” OR	“soft infrastructur*” OR	“soft infrastructur*” OR
“natur* infrastructur*” OR	“natur* infrastructur*” OR	“natur* infrastructur*” OR
“green infrastructur*” OR	“green infrastructur*” OR	“green infrastructur*” OR
“natur* capital”	“natur* capital”	“natur* capital”
NOT	NOT	NOT
“biolog* infrastructur*”	“biolog* infrastructur*”	“biolog* infrastructur*”
AND	AND	AND
“invest*” OR	“means*” OR	“polic*” OR
“financ*” OR	“capacit*” OR	“polic* tool*” OR
“fund*” OR	“willing*” OR	“polic* instrument*” OR
“sponsor*” OR	“contribut*” OR	“polic* framework*” OR
“develop*” NOT	“resourc*” OR	“legal framework*” OR
“investigat*”	“support*” OR	“polic* mechanism*”
AND	“develop*”	AND
“need*” OR	AND	“partnership*” OR
“driv*” OR	“partner*” OR	“collaborat*” OR
“caus*” OR	“privat* landowner*” OR	“co?perat*” OR
“motiv*”	“landdown*” OR	“cooperat*” OR
AND	“landhold*” OR	“institution* support*”
“Agri-Environment Schemes”	“farmland*” OR	AND
	“farmer*” OR	“Agri-Environment Schemes”
	“stakeholder*”	
	AND	
	“Agri-Environment Schemes”	

Note: * shows the use of wildcards or truncated words to retrieve alternative word endings.

The limitation of our methodology is that we cannot entirely guarantee the inclusion of every relevant study due to different languages and unavailability of full-text resources of some sources.

In total, 751 sources were retrieved from databases and Google. Many of the sources that were used were obtained from relevant conservation journals. In the end, 152 sources were distilled.

Results

Needs and drivers for investing in EI

The results show that various drivers necessitate governments and private sector (private commercial companies and non-profit organisations and occasionally civil society members) to take initiative to invest in EI. The motives for investments varied (Table 2, listed in ranks) depending on investor type and tenacious natural or anthropogenic pressures, for example, natural disasters induced by global climate change and agricultural intensification (land-use and land-cover change). The need to protect and conserve biodiversity and to mitigate

the effects of agricultural intensification are amongst the biggest drivers of investments in EI.²⁰ Investments are mainly driven by government for sustainability and by the private sector for social responsibility. Livelihood enhancement through ES (provisioning, regulatory cultural and support services) delivery while sustaining the EI is also an instrumental driver of investment. Other drivers included adapting to and mitigating the effects of climate change and natural disasters and to decrease their severity, and water resource protection.²¹ Government remains the leading investor to address all the EI investment drivers/needs categories.

Willingness to invest in EI

The importance of understanding the desire and willingness of private landowners to adopt conservation practices, and participate in and contribute to EI investments is well recognised.²² This subsection reviews the willingness of private landowners in conjunction with public institutions to accept investment responsibility. Factors associated with willingness determinants and how they relate to each other were also assessed.

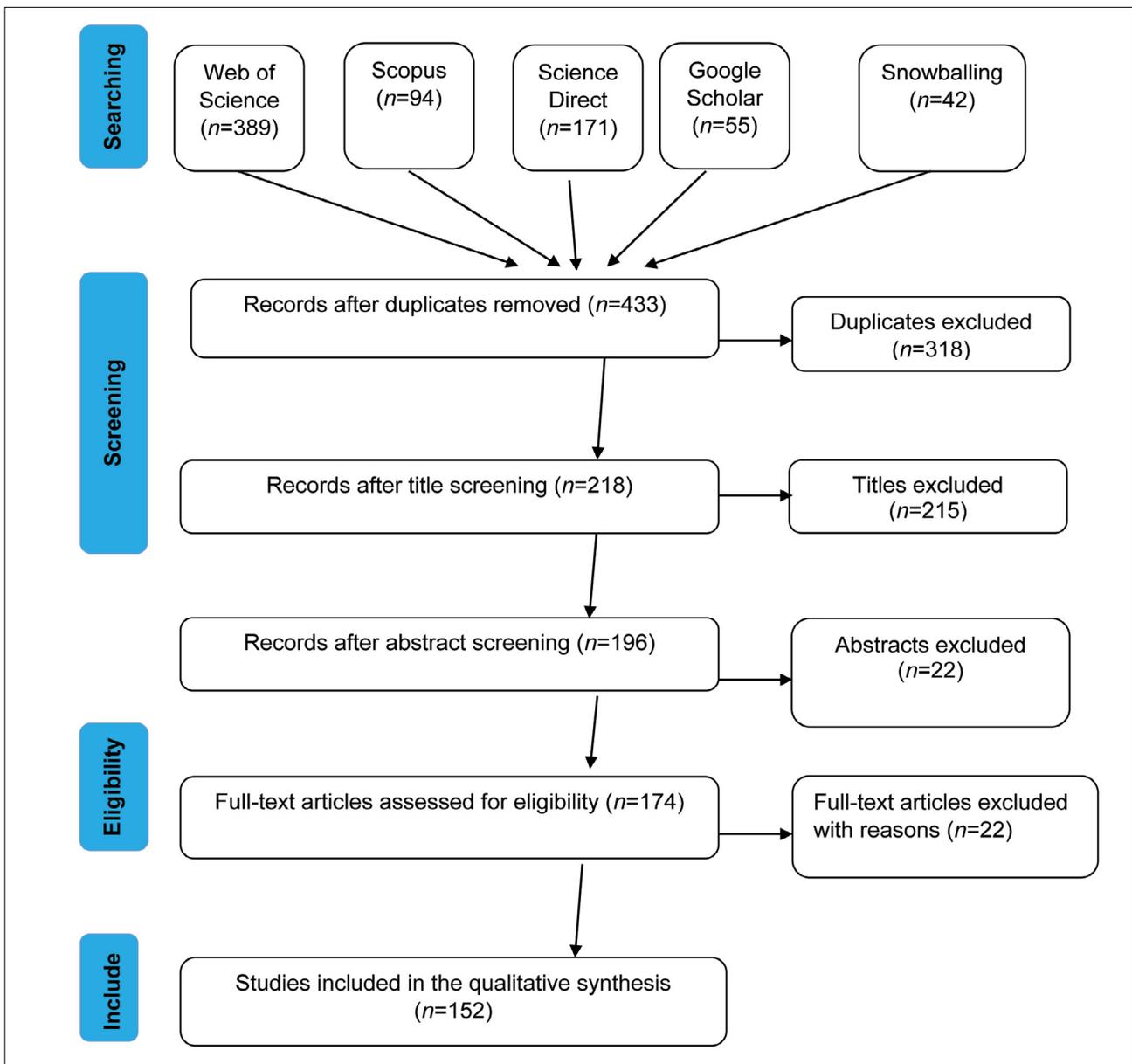


Figure 1: PRISMA diagram sketching the results of articles at searching and screening phases from different databases and sources.

Table 2: The needs or drivers that necessitate investments in ecological infrastructure by different investors. Categories of needs and drivers were derived from ATLAS.ti coding of $n=152$ sources reviewed.

Needs or drivers category	Ecological infrastructure investment needs/drivers	Frequency of mention (%)	Ecological infrastructure types	Top-ranking investors per resource and support	Nature of pressure triggering the needs
Biodiversity protection	Enhancement and conservation of biodiversity Eradication of invasive species Protection of biodiversity on private land Habitat protection and maintenance Restoration of endangered ecological communities	27%	Wetlands Forests Endangered species Rivers Ecological communities	Government Private Sector	Natural and anthropogenic pressure
Agricultural or agronomics	Mitigation of detrimental impacts on terrestrial and freshwater ecosystems due to agricultural activities Addressing the impact of land-use and cover change Mitigation of soil erosion	25%	Terrestrial ecosystems Freshwater ecosystems Ecological landscapes	Government Private Sector	Anthropogenic pressure
Ecosystem services and human well-being	Protection of ecosystem services delivery (provisioning, regulatory cultural and support)	20%	Terrestrial ecosystems Wetlands Biodiversity corridors	Government Private Sector	Natural and anthropogenic pressure
Climate change and natural disasters	Lessen drought caused by climate change scenarios Reduction of greenhouse gases Minimise flood risk Carbon sequestration Wildfire risks and extreme disruptive events	14%	Forests Wetlands Landscape/terrestrial ecosystems	Government Private Sector	Natural and anthropogenic pressure
Water management	Address storm-water challenges Improvement of water quality and quantity Protection of water catchments for biodiversity and human well-being	14%	Rivers Catchments Wetlands	Government Private Sector	Natural and anthropogenic pressure

The emerging review themes and frequency of mentions indicate that private landowners' enthusiasm is influenced by five main determinants and the power of the relationship amongst these determinants.

Funding provided and compensation measures encourage private landowners to participate and implement EI rehabilitation and maintenance measures on their land.²³⁻²⁵ Compensation measures are delivered through the application of market-based conservation instruments, such as economic-based policies that incentivise participating private landowners to deliver ES and comply with the legislation (Figure 2). Socio-economic characteristics and advantages including land ownership, larger farm size, access to information, public awareness and advocacy were stimulating willingness to cooperate towards EI investment, particularly in developed countries. Private landowners who are environmentally conscious, older, experienced in conservation and have a tertiary level education are more likely to participate and steward conservation (Figure 2: Conservation ethics, values and philosophy). Sensitive natural environments and distinctive features trigger conservation interest; Figure 2 shows that where there were unique environmental features such as endangered ecological communities, wetlands and marine assets, many private landowners

were keen to counteract degradation through investments and protecting a natural asset they value or rely on. Conservation activism demonstrated by civil society members and non-governmental organisations also placed pressure on authorities and implicated landholders to make contributions towards investments.

Institutional support mechanisms to encourage EI investments

(a) Public policy

The review showed that public institutions and private landowners invest in EI through policy implementation, management, political support, and self-directed environmental awareness and support to advocacy by NGOs.^{25,26} Generally, public policies emphasise regulatory enforcement and compliance which compel landowners to implement ecosystem-based management interventions (such as rehabilitation and maintenance) to address EI degradation and loss.^{27,28} However, in Latin America and countries such as Finland, policymakers are designing conservation strategies which incentivise landowners to execute sustainable land-use practices that deliver ES, minimise environmental risks and maximise socio-economic development benefits.²⁹⁻³¹

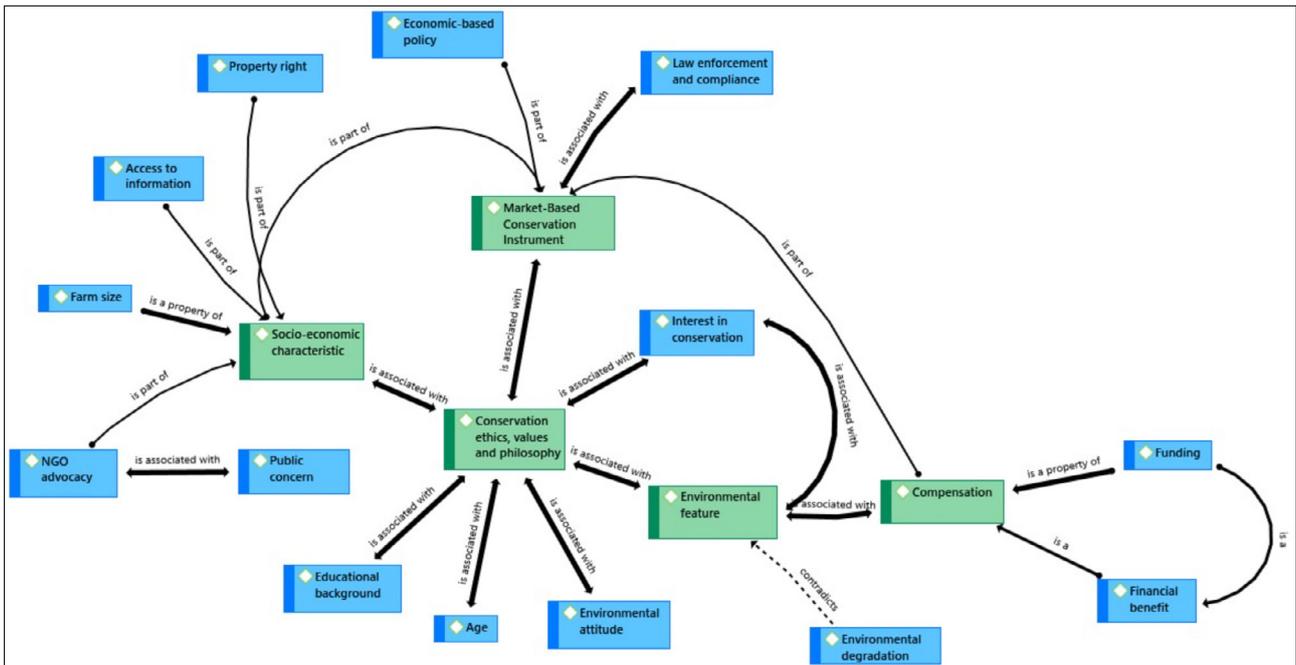


Figure 2: A cognitive map from the review of determinants of willingness to invest in ecological infrastructure by private landowners and other institutions.

(b) Lessons learnt from AES

European Union state members formed incentive programmes to stimulate EI conservation and enhancement on farmlands.³² These programmes subsidise private landowners who voluntarily adopt and implement agri-environment measures.^{16,33} Although AES are widely recognised as major instruments to curb degradation³⁴, some scholars criticise their efficiency to fully conserve the rural landscape^{35,36}. This criticism stems from narrow conservation approaches which focus on individuals or farm-level contracts that are insufficient to achieve wider landscape protection.³⁷ AES have primarily focussed on incentivising private landowners to comply with schemes’ norms and standards (action-based measures). The emerging literature^{34,38} suggests that payments should be driven by the desired results (results-based measures)²³.

(c) Public–private partnerships

Public–private partnerships (PPP) are used as cooperative mechanisms to mobilise funding for public goods and services.^{39–41} They require effective collaboration between local, provincial and national authorities and government agencies; communities/groups; private landowners; private investors; business sectors; non-governmental organisations; and individual civil society members.^{42,43} PPPs have grown rapidly, globally, and have become essential vehicles to encourage private sector investments in conservation.^{43,44} However, the current role and commitment of the private sector in long-term arrangements is still insignificant, particularly in developing nations. As a result, PPPs are not mobilising sufficient funding to alleviate EI degradation.⁴⁵

(d) Market-based conservation instruments

Market tools and economic-based mechanisms have been formed to enable ecosystem goods and services delivery, economic growth, and development while protecting EI.⁴⁶ These funding vehicles are known as Biodiversity or Conservation Banks.^{47,48} They are guided by different policy tools, systems, processes and procedures in different nations. Examples include mitigation biodiversity offsets, mitigation banking, habitat banking, species banking, wetland mitigation, etc.^{49,50} They provide compensatory mechanisms through investments to counterbalance degradation and damage resulting from economic practices and developments, and to support interventions that deliver conservation outcomes.^{47,51,52} The investments mobilised are used

for restoration, maintenance, conservation, and protection of EI and conservation of endangered species.

Discussion

We discuss the implications of the findings on the drivers of investments in EI, the willingness of private landowners to invest in EI and the support mechanisms in place to encourage investments. We present lessons learnt and recommendations to inform and advise natural resources managers and policymakers based on evidence.

Needs and drivers of EI investments

When reviewing the most fundamental drivers or key needs for investments in EI, it was ascertained that conservation, natural disasters, and socio-economic needs put pressure on various institutions and role players to formulate sound measures to restore and rehabilitate (focus on biodiversity and function) and sustain EI. The prevalence of natural disasters and environmental risks stimulate environmental interest because vulnerable landscapes threaten different assets and economic practices. For example, in South Africa, the frequent occurrence of high-intensity and extensive fires, alien plant invasion, and droughts have detrimentally affected EI and economic activities, particularly in the agricultural and forest sectors.⁵³ The review corroborated the recognition of maintaining and restoring EI as a sustainable technique to abate socio-economic and ecological vulnerabilities and risks.⁵⁴ Safeguarding a healthy EI to tactically address climate change related disasters and ecosystem-based adaptation measures have become popular approaches in both ecosystem and livelihood spheres in both developing and developed countries.⁵⁵ In its healthy condition, EI contributes to human livelihood improvement and enhances socio-economic development through ES delivery.⁵⁶ Drivers of investments in EI can be categorised as ‘natural’ and ‘anthropogenic’; they require both public and private investment attention (Table 2). Therefore, EI maintenance and restoration complement land productivity and economic growth, and safeguard food security. Both private and public institutions are anticipated to devise and implement effective ecosystem-based management interventions, ranging from policies to programmes that mitigate EI degradation.

Willingness and desire to invest in EI

Although the investment contributions could not be quantified, the results revealed that, globally, private landowners are willing to participate and invest in EI when there are compensation measures in place.

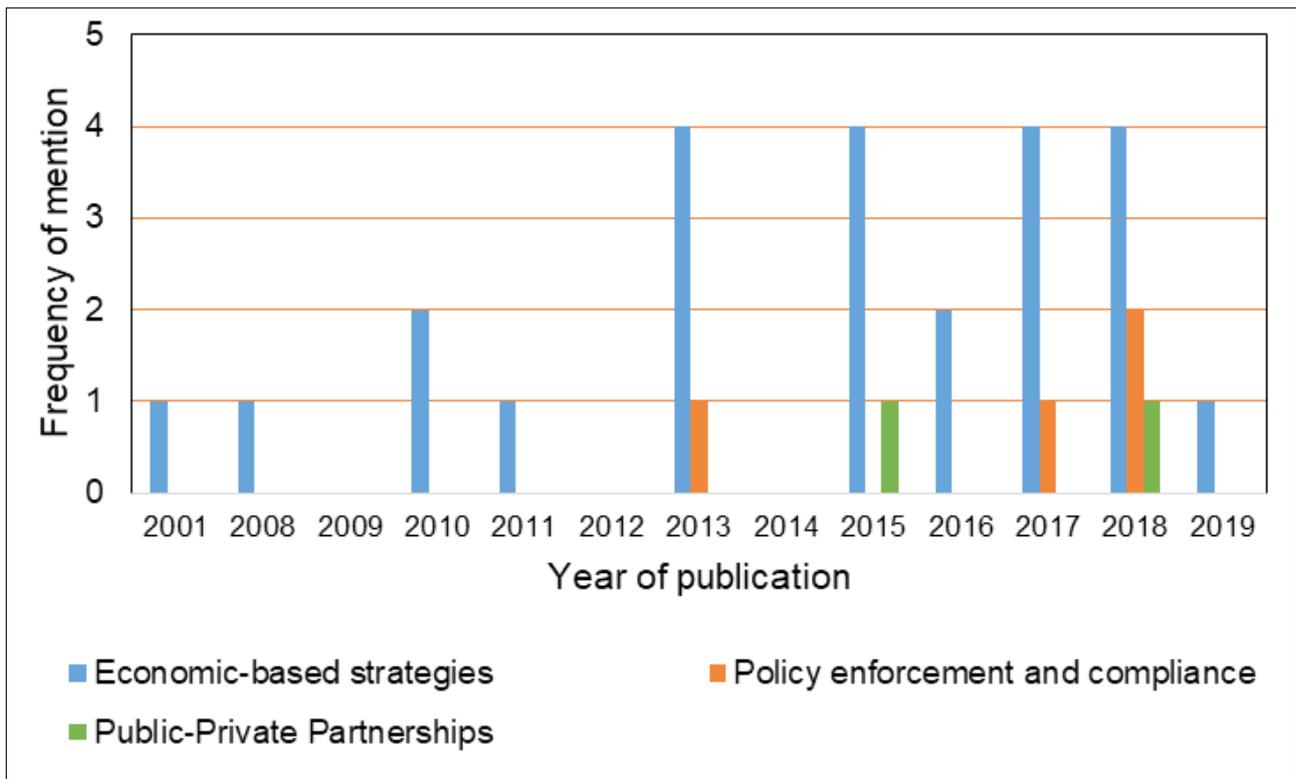


Figure 3: Frequency of mention of economic-based strategies, policy enforcement and compliance, and public–private partnerships in the selected literature over the past two decades.

Financial incentives and funding are generally provided by the government to private landowners who deliver ES through EI management. This analysis suggests that incentive-based policies are pivotal in encouraging the willingness to participate in EI programmes.⁵⁷ Beyond awarding economic incentives to attract public and stakeholder participation, there are other critical determinants that define possibilities of stewarding a landscape. Conservation ethics, values and philosophy either encourage or discourage participation and acceptance of the responsibility to restore and maintain EI. Where socio-economic conditions are favourable, private landowners are more likely to conserve EI. These conditions include land rights, land ownership and tenure security; access to information to awaken conservation interest; bigger farm sizes; higher levels of education and communication and advocacy support from both conservation organisations and government; active neighbourhood networks; private landowner conservation consciousness and interest as well as unique and prominent biophysical environments and features.^{58–60} Considering the above determinants, environmental education and awareness campaigns, advocacy, and communication are vital to support conservation interest and willingness to invest. Stakeholder relations and effective community engagements stimulate a willingness to join conservation initiatives. The establishment of economic-based instruments that offer incentives is therefore instrumental in stimulating willingness to invest in EI. However, these must be intertwined with regulatory and law enforcement approaches that aim to protect the EI.

Institutional support mechanisms and policy regime

The results revealed that diverse investment instruments are executed by either public or private institutions to manage EI in both public and private landscapes. Major institutional investments are financial mechanisms such as incentives and policy frameworks for improved governance. Through these investments, conservation programmes and funds are established to achieve conservation goals for EI while enhancing economic and social prosperity.⁶¹ This dual approach is essential amongst developing economies, particularly in South Africa where conservation programmes are anticipated to generate both ecological and socio-economic deliverables on one budget.⁶² Where ‘win-win’

solutions are expected, a comprehensive approach is applied to gather different stakeholders to form PPPs to mobilise funds from multiple sources.⁴¹ The popularity of PPPs in the global conservation community has grown due to shrinking funding^{39,48} and a desire to strengthen partnerships with the private sector. This investment approach could lead to a long-term collaboration and partnership between different sectors; however, prior to formal agreement, all partners must have an equal understanding of partnership goals and anticipated outcomes to avoid conflict.³⁹ The key potential role players in these partnerships are envisaged to be communities, government agencies, private landowners or users, private investors, business sector, NGOs and individual civil society members. For the South African context, NRM should reinvigorate institutional relations with other national departments that hold a coinciding conservation mandate. The national departments with a conservation mandate could commit funds and cooperate in the coordination of institutional arrangements that seek to implement and monitor EI restoration and maintenance programmes.

This review showed a shift away from command and control measures which emphasise policy compliance⁶³ to economic-based instruments which reward voluntary contributors to ES maintenance^{22,64,65} (Figure 3). These instruments go beyond compensating private landowners for avoiding practices that potentially damage EI to demonstrable ES delivery. This approach suggests that investments made in EI restoration and maintenance must be justified; therefore NRM programmes should emphasise rewarding conservation interventions based on ecological outcomes.^{45,66} Results-based programmes are more justifiable than action-based programmes to provide evidence towards making the ecological investment case.

The South African NRM programmes should define monitoring measures that demonstrate positive ecological outcomes emanating from the interventions. Anticipated outcomes and monitoring protocols must be clarified accordingly. Dedicated data collectors and analysts should define indicators and present the information to key NRM stakeholders and beyond to secure buy-in.²⁹

Recommendations and policy implications

Recommendations were extracted from the review to inform conservation policy- and decision-makers about available evidence and insights necessary for 'unlocking and securing EI investments'. These recommendations may vary among countries depending on policies and approaches. In the South African context:

- Ecological infrastructure investment funds should be clear on anticipated outcomes and set a precise monitoring system and indicators. Application of remote sensing satellite imagery coupled with site inspections could be used to monitor ecological changes.⁶⁷
- Biodiversity stewardship programmes are vital in the management of EI. Through a holistic landscape conservation approach, a group of landowners could be assigned an ecological landscape to maintain collectively. Benefits and incentives could be distributed and shared evenly.
- Advocacy and communications should be strengthened to improve awareness, build capacity and awaken conservation interest. Clear messaging on EI rehabilitation benefits could leverage political and social support for EI investment.
- Formation of PPP could scale up investments. Mobilised funds from environmental and water sectors, insurance companies, international funding agencies for climate change, carbon tax funds, corporate institutions, and philanthropists could be used to establish risk mitigation support mechanisms to protect businesses, deliver ES and enhance long-term protection of EI.
- South African national departments with overlapping conservation mandates should break silos by strengthening conservation engagements, coordination of investments and collaborative partnerships.⁶⁸
- Community of practice platforms (e.g. MaReP Forums) should be utilised where knowledge and learning exchange occurs between conservationists, researchers, managers, planners, the private sector, investors and funders. Socio-ecological systems and factors should be analysed, coupled with expert opinions to understand the decision affecting/influencing the keen investors and unenthusiastic parties. Possible investors compared to those who do not take EI into account, can be predicted.

Conclusion

Demanding development needs drive both governments and private landowners to invest and improve EI functionality. The drivers for EI investments are orientated towards improving ES and human well-being. Private landowner contribution is crucial in EI management. Their willingness to engage is stimulated by economic and ecological returns. Financial incentives, compensation, and favourable social conditions encourage private landowners to voluntarily implement interventions and programmes. This review supports and contributes to the evidence-based policy advice by highlighting the measures to instil collaborative partnerships and collective efforts between government and private landowners to maximise investments and expand ecosystem management capacity. Lessons learnt and recommendations made will help policymakers and conservation managers understand effective institutional support mechanisms that have claimed success in 'unlocking and securing EI investments'. More empirical work dedicated to designing economic-based incentives and finance mechanisms is required as well as the demonstration of successes and returns on investments to make the case for investments.

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Competing interests

We have no competing interests to declare.

Authors' contributions

M.S.M.: Conceptualisation, methodology, investigations, data collection and analysis, writing draft manuscript. C.M.: Conceptualisation, methodology, supervision, review and editing, funding acquisition. T.E.K.: Conceptualisation, methodology, supervision, review and editing. K.J.E.: Conceptualisation, methodology, supervision, review and editing.

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