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Ontological Analysis to understand the Interplay between Ecosystem Services, Human Well-being, and Climate Change

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Abstract

This study employs an ontological analysis to critically examine the integration of ecosystem services and human well-being within the context of climate change. The principal objective is to identify research gaps within the existing literature and to propose potential avenues for future research. Our findings reveal significant deficiencies in policy, legal, and procedural frameworks, with a predominant focus on local-level case studies and objective measures of well-being. Notably, cultural and supporting services remain underexplored. These gaps highlight the need for comprehensive research incorporating diverse stakeholder perspectives, adaptive capabilities, and robust policy frameworks to enhance resilience against climate change. The study underscores the urgent need for broader and more inclusive investigations to effectively inform policy-making and sustainable management practices.

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Introduction

Historically, forest ecosystems have covered most of the tropical regions worldwide, and during the course of time, they have been transformed due to agricultural and urban expansions into ageing human-modified landscapes. Tropical regions tend to have highly dynamic landscapes where the ecosystem services are potentially affected by historical land use and current landscape structures.[1,2] Traditionally, pristine habitats with minimal anthropogenic interventions have been the primary focus of ecologists and conservationists, intending to preserve the remaining fragments of wild nature. However, these regions do not represent most of the world's tropical areas. To comprehend the present and predict the future of tropical biodiversity, we need to study the various levels and patterns of biodiversity in areas shaped by human activities like farming, logging, and plantations. Investigating how human practices affect biodiversity in places like fallow lands and forest patches is crucial, as they can host significant levels of diverse

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life.[1,2,3,4] Acknowledging this significance prompted the emergence of the ecosystem services theory, originally conceived to elucidate the advantages natural ecosystems offer to society and to advocate for biodiversity conservation.[5]

The original idea of ecosystem services was first documented by Odum (1959)6 in 'Fundamentals of Ecology', which includes agriculture, forestry, hunting, and fishery.[7] In the 1980s, Elhrich and Mooney used the term ecosystem service, which is widely accepted today.[8,9] Although research on ecosystem services was going on in the past, there were not many publications until 1990s.[7] In 1997, two crucial publications on ecosystem services by Daily (1997) [10] and Costanza *et al*. (1997) [11] changed the research direction.[12] Subsequently, with the publication of the 2005 Millennium Ecosystem Assessment (MEA) report, a comprehensive effort involving over 1300 scientists commissioned by the UN, ecosystem services garnered considerable attention.[13]

Ecosystem services are now widely regarded as a fundamental link between the environment and society and a foundational idea in resource management, ecological and environmental economics, conservation, and resource management. 14 Besides MEA, other international programmes include "The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services "[15] and "The Economics of Ecosystem and Biodiversity "[16] have accelerated ecosystem service research worldwide. In contemporary times, there has been an increased focus on "ecosystem-based adaptation," emphasising the multifaceted roles of ecosystem services and their potential to lower economic costs as a strategy for addressing the risks associated with climate change. Traditional knowledge within local communities contains valuable adaptive practices that can be revived.[17]

Ecologists encounter several primary challenges when conducting empirical or modelling studies of ecosystem services, including comprehending anthropogenically altered ecosystems, analysing the interconnections among ecosystem services, and considering suitable spatiotemporal scales to elucidate the feedback mechanism between nature and human well-being.[5] These challenges are aimed at addressing the risks linked with climate change and devising strategies for their mitigation. The concept of human well-being is gaining a central position in research and policy on ecosystem services and sustainability in general. Despite this, there is still a lot of gap in understanding the tangible role of ecosystem services in improving multidimensional human well-being.[18]

On the other hand, Climate change poses a pressing issue with profound implications for ecosystems and human well-being. The extant literature has comprehensively documented that escalating global temperatures, shifting precipitation regimes, and augmented frequency of extreme climatic phenomena are profoundly transforming the structure and functioning of ecosystems worldwide.[19,20, 21] These changes affect biodiversity, ecosystem productivity, and ecosystem services vital for human well-being, such as food, water, and air quality.[13,22, 23] Despite the extensive body of research on climate change impacts, significant gaps remain in our understanding, particularly concerning the complex interactions and feedback mechanisms between climate and ecosystem processes.[24,25,26] Addressing these unknowns is critical for developing effective adaptation and mitigation strategies.

The methodologies employed in assessing ecosystem services predominantly centre on ecosystems or habitats, thereby shadowing the recognised influence of spatial land use patterns on ecological processes.[30] Most of the initiatives either disregard or underestimate the intricate relationship between ecological conservation and human well-being. Addressing this issue effectively obliges articulating the complexity of its structure. Effective problem-solving requires highlighting the intricacy of the issue in its totality. This paper attempts to develop an ontological framework for comprehending the intricate integration of fundamental concepts pertaining to ecosystem services, human well-being, and climate change, elucidating their co-evolution throughout the trajectory of research studies. It primarily focuses on identifying the research gaps in the effective integration of these concepts holistically.

Ontological analysis allows for a deeper understanding of the fundamental categories and relationships that define the existence and interactions within an ecosystem. This method

provides a framework for integrating various dimensions of ecosystem services and human well-being, enabling a holistic view of how these elements are interlinked. Through the application of ontological principles, researchers can systematically classify and examine the elements of ecosystems and their associated services, thereby providing a solid framework for evaluating the effects of climate change on both natural and anthropogenic systems.[27,28,29]

Methodology

Ontological Framework

The ontological framework is employed to conceptualise the challenge.[31] It consolidates and structures taxonomies and terminologies, facilitating the recognition and comprehension of the semantics associated with the challenge.[32] Additionally, it organises the description of a complex domain.[33] The framework used here is based upon Ramaprasad and Mitroff's framework which organises the components of a domain using the natural language of that domain. Unlike ontologies generated automatically from large datasets, this is deduced from the definition of the domain, applied to key documents, and refined until it fits well. As outlined by Ramaprasad and Mitroff (1984),[34] the process primarily focuses on key nouns, verbs, and occasionally adjectives that define the domain and their interrelations. Refinement, application, and abstraction constitute successive stages in this process. Chandrasekaran *et al*. (1999)[35] propose organising fragments of research on the problem using a straightforward conceptual framework. This framework can be likened to a simplified theory of the problem.[36] Various studies, including the ontological meta-analysis and synthesis of mHealth,[37] investigations in public health informatics,[38] examinations of climate change,[39] policy analyses,[40] and research in other domains, have all employed this approach.

The subsequent section elucidates the ontological framework, delineating the rationale behind its development and validation. Subsequently, the framework is employed to elucidate the intricate relationship between ecological health and human well-being, alongside identifying associated research gaps. The study endeavors to map the interconnections among ecosystem services, human well-being, and climate resilience, with the aim of highlighting (a) the varying degrees of emphasis on elements within the framework, and (b) the primary (heavily emphasised), secondary, tertiary, quaternary, and quinary (neglected) pathways in conceptual linkages. Furthermore, the authors deliberate on how "informating" [41] —enriching with data, their analysis, interpretation, and application— could potentially unveil new avenues and alter perspectives on understanding ecological dynamics and its conservation in the context of human well-being. The illustration of the framework is given in Fig. 1, and its components are defined in the Glossary provided in Annexure 1. The construction of the framework is elaborated upon in subsequent sections

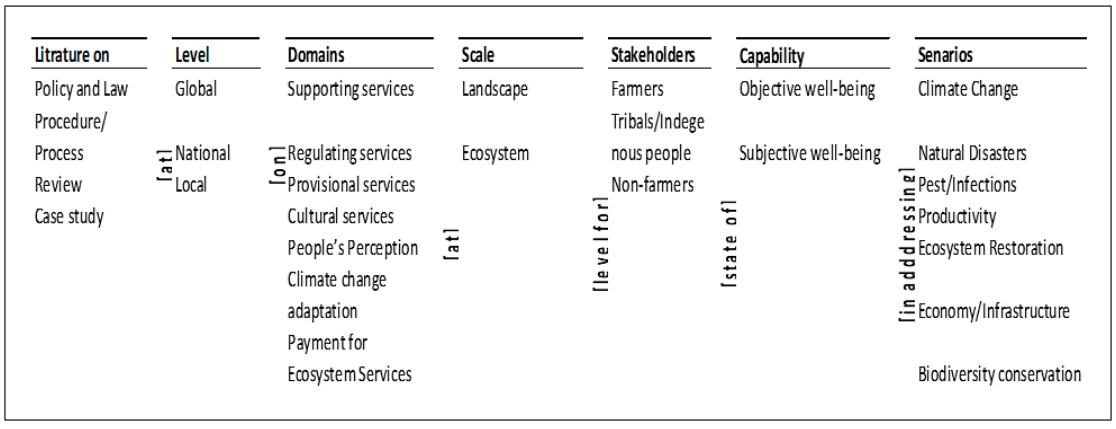

Fig. 1: Ontological framework for identifying research gap in integrating ecosystem services, human wellbeing and climate change

At the highest tier of the hierarchical structure, the framework portrays the intricate nexus between ecosystem services, human well-being, and climate change through a concatenation of Literature, Level, Domains, Scale, Stakeholders, Capability, and Scenarios. This concatenation is linguistically and logically articulated, rather than relying on algebraic or arithmetic addition. Thus:

Interlinkages between ecosystem services,human wellbeing and climate change= f(Literature + Level +Domains + Scale + Capability + Scenarios)

At the consequent level, each dimension is delineated through a subsequent taxonomy of elements. These taxonomies are rationally constructed, taking into account the possibilities and fundamental conceptual linkages required for an all-encompassing strategy to recognise the role of ecosystem services in vulnerable communities' well-being and to strengthen their resistance to the negative effects of climate change.

Table 1. Dimensions and elements used in Ontological Framework

Sl. No.	Dimensions	Elements
1	Literature	Policy and law, Procedure/ process, Review, Case Study
2	Level	Global, National, Local
3	Domains	Supporting services, Regulating services, Provisioning services, Cultural Services, People's Perception, Climate Change adaptation, Payment of Ecosystem Services
4	Scale	Landscape, Ecosystem
5	Stakeholders	Farmers, Tribals/ Indigenous people, Non-farmers non-tribals
6	Capability	Objective well-being, Subjective well-being
7	Scenarios	Climate change, Natural Disasters, Pest/ Infections, Productivity, Ecosystem Restoration, Economy/Infrastructure, Biodiversity conservation

The seven dimensions' constituent parts are arranged sequentially from left to right, interconnected by linking concepts such as symbols, words, and phrases. This arrangement forms coherent English sentences that illustrate the intricate interplay among ecological services, human well-being, and climate vulnerability adaptation (Fig. 1). The framework encompasses a total of 7,056 components. Table 1 details the dimensions and components within this framework. From this comprehensive structure, the following seven exemplary elements can be derived:

1. Components emphasised in the literatures including policy and/or law, conceptual process or procedures, reviews and case studies.
2. The level of coverage of the paper i.e., if its addressing the issue at global, national or local scale.
3. The domains addressed by the paper focusing on Ecosystem services (Supporting services, Regulating services, Provisioning services, Cultural Services), People's Perception, Climate Change adaptation and Payment of Ecosystem Services.
4. The scale at which the issues are addressed. Whether it is focusing on one isolated ecosystem or landscape as a while.
5. The stakeholders whom the study is either directly or indirectly addressing. Most of the times it's the vulnerable population like farmers and Tribals/ Indigenous people.
6. The capability of the community addressed in the preview of there subjective and objective well-being.
7. The scenarios the study address including Climate change, Natural Disasters, Pest/ Infections, Productivity, Ecosystem Restoration, Economy/Infrastructure and Biodiversity conservation

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There are 7,056 components in the ontology, some of which may be instantiated frequently, seldom, or never. There are several methods for instantiating a component, and one instantiation may encompass more than one component. Moreover, certain components might only be instantiated in fragments, while others might be instantiated in whole.

Validity of the Ontological Framework

The ontology represents a hierarchical depiction of a combinatorially complex construct, characterised by its novel assembly and organisation within the domain. The interpretability of the produced natural English components, which are understandable to both experts and beginners, demonstrates its notable high semantic validity. Semantic validity depends only on linguistic interpretability; it is not reliant on whether a component has been or can be instantiated. The face, content, semantic, and systemic validity of the framework are emphasised via the use of established validity constructs. Additionally, external validation from domain experts is pursued to confirm its credibility.[38,39,40]

An integrated approach is necessary to recognise the contribution of ecosystem services to the well-being of marginalised groups and their ability to withstand the negative effects of climate change. The framework's dimensions, taxonomies, and resulting pathways present a comprehensive and closed representation of potential and essential conceptual linkages. The framework demonstrates high systemic validity and is designed with modularity, allowing for the addition, removal, or modification of dimensions and elements based on feedback from research publications to maintain conciseness and comprehensiveness. Striking a balance between parsimony and completeness is essential, as an excess of dimensions and elements could result in complexity, while very few may lead to oversimplification and invalidity. The framework's validity is ultimately contingent upon the accuracy with which ecosystem services, well-being, and climate change components are mapped onto it. Furthermore, it depends on the framework's effectiveness in illustrating the advantages and disadvantages of incorporating these aspects into research publications.

Data Selection and Coding

The data selection and coding was carried out in three steps: identification of literature, Screening of papers using inclusion and exclusion criteria and coding of papers under relevant heads.

The Web of Science (WoS) database was searched in order to find publications that included pertinent keywords. Established by Eugene Garfield in 1964, WoS is the oldest, most widely utilised, and most reputable database for research papers and citations globally. Based on the Science Citation Index, the WoS Core Collection database provides a comprehensive citation index that encompasses academic and scientific publications across books, journals, conferences, and data sets.[42] While alternative search engines exist, this study confines itself to the Web of Science due to its rigorous and highly authoritative peer-to-peer review process, ensuring the dissemination of research papers that adhere to elevated standards.

WoS data base was searched for the articles with the key words "Ecosystem Services", "Climate Change", "people", "forest" and "Ecosystem services", "Capability approach". About 340 research papers were downloaded with these key words. Further the papers were sorted in accordance with the relevance of the study and the number of papers were reduced to 200 based on title and abstract. The abstracts were screened to exclude false positives, as well as the articles using contextual keywords with no solid relevance to the framework. Additionally based on the availability of the full texts the number of papers included for in-depth analysis were further reduced to 189. The binary coding was carried out only for the 171 papers and rest of the 18 papers were eliminated as they did not fit into the framework.

There is an exponential increase in number of papers published from 2008 to 2021 (Fig 2). This trend underscores the increasing significance of comprehending the interconnections and synergies among ecosystem services, human well-being, and climate change. This surge in research activity is particularly notable following the emergence of the Millennium Ecosystem Assessment (MEA) in 2005 and other international initiatives, which

have significantly propelled the study of ecosystem services. Notably, there has been a substantial emphasis on adopting a holistic perspective that integrates human well-being and considers the impacts of climate change.

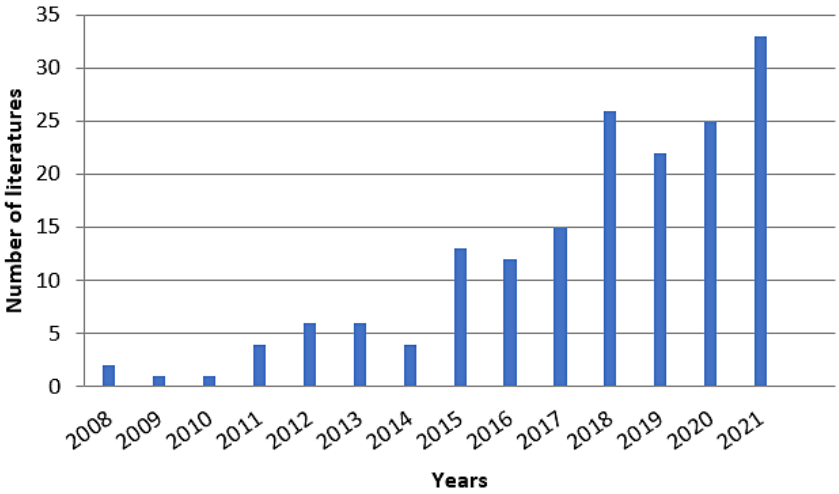

Fig.2 Number of publications in Web of Science integrating ecosystem services, human well-being and climate change

Results and Discussions

The Ontological map of identifying research gaps in integrating ecosystem services, human well-being and climate change is given in Fig.3. The frequency of each element within the corpus is indicated by the number in parentheses beside it. The relative frequency of each element is visually represented by the bar beneath it. The maximum frequency for any element is 170, corresponding to the total number of sources in the corpus, which would occur if the element were referenced in every source. For instance, [42] literatures talk about supporting services. The number in parentheses next to each dimension descriptor indicates the frequency with which that dimension appears in the literature. A single piece of literature may discuss multiple aspects of one dimension, leading to a dimension's frequency potentially being lower than the sum of the frequencies of its constituent parts. For example, while scenarios are mentioned in 130 pieces of literature, there are 314 total scenarios because some sources reference multiple scenarios. The findings of the ontological map are summarised as follows.

In the following section, the article discusses the results of identifying the research gap in integrating ecosystem services, human well-being and climate change:

Taxonomy Analysis

This section explores the elements organised across the seven dimensions, providing a discussion that includes the frequency of literature occurrences for each dimension and its respective elements.

Literature

The maximum number of the literatures emphasised in the framework are case studies (108 out of 171 are case studies). Followed by reviews (44) and very little emphasis on Policy and Law (10) and Procedure/ Process (11).

Level

Except for the literatures on procedure/ process, every other literature represent the issue in either Global, National or Local scales. Most of the literatures stresses on Local level (93) followed by Global (42) and National (33).

Domains

Regulating services (98) and Provisional services (85) are the domains getting greater emphasis in

the literatures. Further, People's perception (60), Cultural Services (58), and Supporting services (42) find moderate attention; where as Climate Change Adaptation (31) and Payment of Ecosystem Services (36) are the least.

Scale

Most of the literatures are addressed at the landscape scale (87) out of very few of them are restricted to scale of isolated ecosystem (31).

Stakeholders

Only ~42% of the literatures (72 out of 170) include stakeholders in the studies. Of which major importance is seen towards Tribals/ Indigenous people (41) followed by Farmers (29) and Non-farmers Non-tribals (28).

Capability

Very little emphasis is given to capability of the stakeholders in provisioning there objective (42) and subjective (20) well-being.

Scenarios

Climate Change (85) and Biodiversity Conservation (75) are the scenarios majorly highlighted in the literatures. Where as no major emphasis is found over Natural Disasters (36), Ecosystem Restoration (36), Economy/ Infrastructure (34), Productivity (32) and Pest/ Infection (16).

Among the literatures reviewed, it was found that majority of the literatures were case studies majorly highlighting the local scenarios. The studies extensively used community perception studies to understand perspectives and utilisation patterns of Ecosystem services, habitat and biodiversity conservation, adaptation to extreme climate change scenarios and Natural disasters, Payment of Ecosystem in context of sustainability, capabilities and community well-being. Number of studies also used RS and GIS tools and models to map the Ecosystem services and vulnerabilities of the various landscapes, spatiotemporal changes of the landscapes and Payment of Ecosystem services. Among these papers, provisioning and regulating services were particularly emphasised. This reflects the skewness of researchers towards provisioning and regulating services over supporting and cultural services, which can be related to the objectiveness of these services and the straightforwardness associated with the evaluation process of the provisional and regulating services. This observation underscores a potential inclination within researchers to prioritise domains that lead them to more objective and streamlined assessments.

The idea of "payment for ecosystem services," or "PES," has gained popularity recently as a way to solve environmental issues and advance the more general objective of striking a balance between ecological integrity and human progress. In spite of this, only 36 papers have talked about PES. Of these, [24] are case study papers, seven are reviews, and only three are on PES assessment methods and two are papers on policy implications. Even among case studies, few exclusively focus on specific ecosystems, unable to capture the trade-off across adjacent ecosystems.

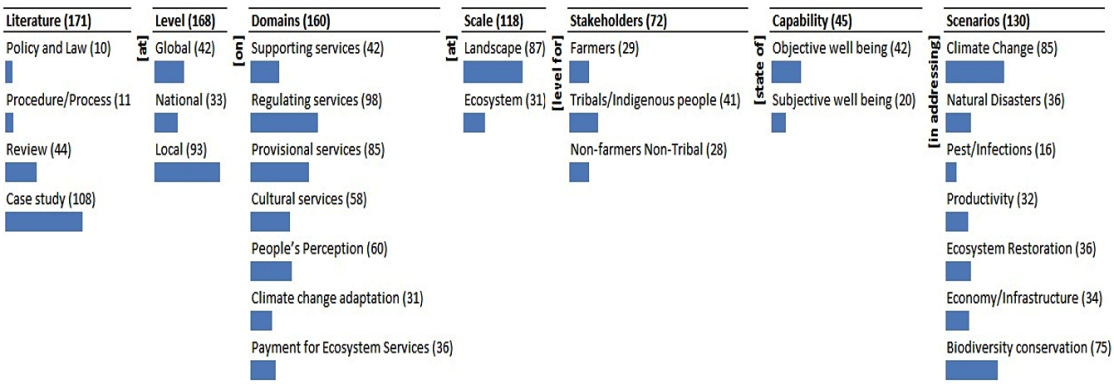

Fig. 3: Ontological map of identifying research gap in integrating ecosystem services, human wellbeing and climate change

Thematic Analysis

The following section discusses the strength of interrelations across each dimension and its subsequent taxonomic elements. Thematic analysis has classified such interrelations into primary, secondary, tertiary, quaternary and quinary themes (Fig.4). The primary theme represents the dominant topic covered in the literature, serving as the foundation for these works. Conversely, the quinary theme denotes the main topic absent from the literature, highlighting unaddressed areas. Themes that fall between these two extremes reflect varying levels of presence or absence in the literature.

Primary theme

Case study-Literature at Local- Level on Regulating services- and Provisional Services – Domain at Landscape –Scale in addressing Climate Change - Scenario. It does not address Stakeholders and Capability.

Secondary Theme

Review – Literature at Global – Level on Cultural Services - and People's Perception –Domains level for Tribals/ Indigenous People – Stakeholders state of Objective well-being – Capability in addressing Biodiversity Conservation. It does not include scale.

Tertiary Theme

Supporting Services – Domain in addressing Natural Disasters- Ecosystem Restoration- and Economy/ Infrastructure- Scenarios.

Quaternary theme

National – Level on Payment of Ecosystem Services – Domains Productivity – Scenarios find least mention in the literatures are in Quaternary theme

Quinary theme

Policy and Law and Procedure/Process – Literature on Climate change adaptation – Domain at Ecosystem – Scale at the level of Farmers - and Non-farmers Non-Tribals – Stakeholders to state of Subjective Well-being – Capability in addressing Pest/ Infections. These elements finds feeble emphasis among the literatures.

The primary objective of this study was to identify and elucidate the gaps in the current literature concerning the integration of ecosystem services and human well-being within the context of climate change. The ontological analysis revealed significant deficiencies in existing research, particularly in the areas of policy, law, and procedural frameworks. Highlighting these gaps is crucial, underscoring the need for more comprehensive and inclusive studies to better understand the complex interactions between ecosystems and human communities.

Approximately 85 scholarly papers are dedicated to examining the complex intersection of climate change and ecosystem services. However, it is noteworthy that there is a lack of comprehensive studies focusing on the holistic integration of ecosystem service utilisation patterns among different stakeholders. Furthermore, there is a noticeable gap in exploring diverse perspectives regarding how such integration could enhance stakeholders' adaptive capacities in response to climate change. Even the available papers addressing the Capabilities focus on objective well-being (42) over subjective well-being (20). Among them, only 17 papers address both Objective and subjective well-being. Only five of them explicitly engage in a holistic exploration of the interplay between ecosystem services, climate change, and the capabilities of communities.[43,44,45,46,47,48] Among the stakeholders, it is seen that the majority of the studies revolve around tribals or Indigenous communities, as these communities live closer to nature and have historical and cultural ties with forests. Apart from Climate Change considerable works are carried out in other scenarios including Biodiversity Conservation (75), Ecosystem Restoration (36) and Natural Disasters (36) which majorly revolves around forests. However, the scenarios of Productivity (32) and Pest/infections (16) mainly revolve around agriculture and such studies were comparatively fewer than others.

Chen *et al*. (2017)[17] also highlighted similar gaps, emphasising the lack of knowledge in adapting to climate change-induced natural disasters and the influence of land use on biodiversity and disaster risks. Effective disaster risk adaptation is critical to the sustainability of local and global human societies. For instance, in India, vulnerability studies have predominantly concentrated on understanding how social factors influence adaptation practices in agriculture.[48] However, aspects such as culture,

tradition, and strategies based on indigenous knowledge are underexplored.[49] Although the Millennium Ecosystem Assessment (MEA) advocates for examining the connections between ecosystem services and human well-being to guide decision-making at local, regional, and global levels, there is scant attention given to human well-being and a complete lack of focus on human capabilities.[50]

The results of this study reveal several critical insights into the integration of ecosystem services, human well-being, and climate change. The ontological analysis uncovered significant deficiencies in understanding the complex interrelations between these components, particularly in policy, law, and procedural frameworks. For instance, the analysis identified that case studies predominantly emphasise local-level scenarios focusing on regulating and provisioning services. In contrast, broader thematic areas, such as cultural and supporting services, remain underexplored. Moreover, the skewed emphasis towards objective well-being over subjective well-being highlights a gap in comprehensively understanding human well-being in the lens of ecosystem services. This study underscores the need for more holistic approaches incorporating diverse perspectives and adaptive capacities of various stakeholders, including indigenous and tribal communities, to address climate change impacts effectively. These identified gaps call for future research to prioritise inclusive and multidimensional frameworks that can better inform policy-making and sustainable management practices.

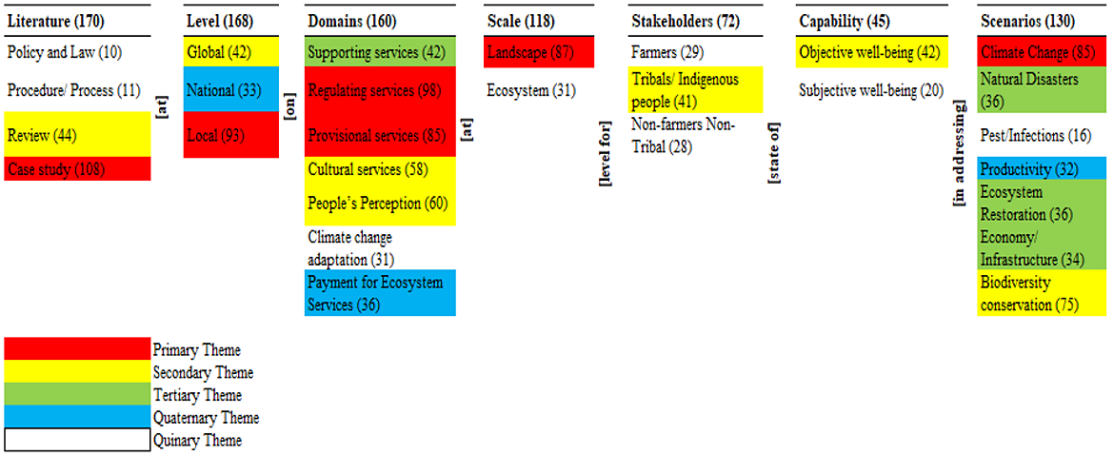

Fig. 4: Themes of identifying research gap in integrating ecosystem services, human wellbeing and climate change

Conclusion

The concept of human well-being is gaining a central position in research and policy on ecosystem services and sustainability in general. Human-dominated landscapes can be conceptualised as comprising two interconnected components: social systems and ecological systems. Each of these components consists of multi-level organisations that interact in a complex manner. Despite this, the present review uncovered that, there is still a lot of gap in understanding the tangible role of ecosystem services in improving multidimensional human well-being. In addition, there is an apparent gap in the investigation of varied viewpoints concerning how the integration mentioned could augment the adaptive capabilities of stakeholders confronting the challenges posed by climate change.

Further, it can be seen that there is a graded emphasis on case studies among literature reviews over papers related to procedure/process, policy, and law. Despite the emergence of studies integrating Ecosystem services, human well-being and Climate Change in the recent decade, its unusual to see minimal papers explicitly discussing Policy and Conceptual Frameworks. The lack of

detailed conceptual frameworks could also be one reason for very little research in assessing dynamic and complex concepts like Supporting services and Subjective well-being.

It is essential to acknowledge that this review is confined to the examination of the study framework and the available literature within the Web of Science (WoS) database as of March 2022. While numerous papers may be accessible through other search engines such as Scopus or Google Scholar, our study is delimited to WoS, recognised for its widespread trust among researchers globally owing to the high quality of papers attributed to its rigorous peer-review process. Additionally, it is notable that papers indexed in the Web of Science (WoS) receive, on average, 17.5 times more citations than those in the Social Sciences and Humanities. In contrast, this difference is reduced to 7.5 times for papers indexed in Scopus.51 Consequently, it can be inferred that while additional literature might provide insights into the framework, such papers may not meet the stringent quality criteria upheld by WoS.

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Conflict of interest
The authors do not have any conflict of interest.

Data Availability Statement
The manuscript incorporates all datasets produced or examined throughout this research study
Ethics Statement This research did not involve human participants, animal subjects, or any material that requires ethical approval

Authors' Contribution
All authors contributed to the study conception and design. Material preparation and data collection was performed by Kavana R. Analysis was performed by Kavana R, B C Nagaraja and Kumaraswamy T R. The first draft of the manuscript was written by Kavana R and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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Annexure

Annexure 1: Glossary on Ontology dimensions and elements

Literature	–	Research papers downloaded from Web of Science with the selected keywords
Policy and Law	–	Research papers reviewing exclusively on policies or laws
Procedure/ Process	–	Research papers discussing on conceptual frameworks
Review	–	Research papers based on literature reviews
Case Study	–	Research papers addressing specific issues at local, national or global levels through original research works
Level	–	Study area range covered in the research paper
Global	–	Research papers illustrating at the global level
National	–	Research papers illustrating at the National level
Local state,	–	Research papers illustrating at the local level at the scale of Sub-national, city or smaller than that.
Domains	–	Specific research areas the paper is emphasing on
Regulating Services	–	Air quality, Biodiversity regulation, carbon storage, climate regulation, disease regulation, Natural Hazard regulation, Nutrient cycling, Pollination, Shoreline protection, soil stabilisation and erosion control, waste treatment and processing, water quality regulation, water-flow regulation
Supporting services	–	Soil formation, photosynthesis, primary production, Nutrient cycling, water cycling
Provisioning services	–	Food, fibre, fule, genetic resources, biochemicals, ornamental resources, fresh water
Cultural services	–	cultural diversity, spiritual and religious, knowledge systems, education values, inspiration, aesthetic values, social relations, sense of place, cultural heritage

		values, recreation
People's Perception	–	Pieces of literature involving interactions and stakeholder perception illustrated
Climate change adaptation	–	actions that reduce the negative impact of climate change while taking advantage of potential new opportunities
Payment of Ecosystem Services	–	incentives offered to farmers or landowners in exchange for managing their land to provide some sort of ecological service.
Scale	–	The range of biome the study is addressing
Landscape	–	spatially heterogeneous geographic areas characterised by diverse interacting patches or ecosystems
Ecosystem	–	the ecosystem is a community and its physical environment Eg: Forest ecosystem, grassland ecosystem
Stakeholders	–	People who depend on Forest resources and live in nearby Forest areas
Farmer	–	a person who owns or manages a farm
Tribals/ Indigenous community	–	distinct social and cultural groups that share collective ancestral ties to the lands and natural resources where they live, occupy or from which they have been displaced
Non-tribal non-farmers	–	Any other stakeholders other than farmers and tribals. Like forest officers, scientists etc.
Capability	–	the set of valuable functionings that a person has effective access to
Objective well-being	–	Monatary value of ES
Subjective well-being	–	measured by life satisfaction, happiness, or for enabling people to lead their lives in their ways
Scenarios	–	descriptions of probable, possible and/or preferable futures
Climate change	–	long-term shifts in temperatures and weather patterns
Natural Disasters	–	a natural event such as a flood, earthquake, or hurricane that causes great damage or loss of life
Pest/infection	–	crop damages caused due to pest attacks or health alignments caused due to changes in local climatic conditions or pollution
Productivity	–	Crop or any other ecosystem productivity with monetary values
Ecosystem restoration	–	the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed
Economy/ Infrastructure	–	Economy or infrastructural development in the context of conservation and sustainability.
Biodiversity Conservation	–	the protection, upliftment, and management of biodiversity in order to derive sustainable benefits for present and future