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TRANSDISCIPLINARY RESEARCH FOR NATION-BUILDING: A SYSTEMATIC BIBLIOMETRIC ANALYSIS OF CONCEPTUAL DEVELOPMENT AND RESEARCH IMPACT

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ABSTRACT

Transdisciplinary research (TDR) is increasingly recognized as a pivotal approach for addressing complex societal challenges and advancing nation-building objectives. This study systematically investigates the conceptual development, institutional practices, and impact of TDR in Malaysian universities, with a particular focus on private higher education institutions. Guided by three primary objectives, the study aims to (1) assess the current landscape and standards of TDR in universities and (2) identify gaps and potential for enhancing TDR contributions to nation-building. A comprehensive literature review was conducted using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) framework. Peer-reviewed publications were retrieved from Scopus, Web of Science, and ERIC for the period 2012–2025, encompassing theoretical, empirical, and bibliometric studies. A final set of 42 articles was selected following screening and eligibility criteria. Data were analyzed using bibliometric mapping (VOSviewer) and thematic analysis, focusing on institutional barriers, knowledge co-production, policy integration, capacity building, and sustainability-oriented outcomes. Findings indicate that while TDR is conceptually established, its operationalization in Malaysian universities remains fragmented due to institutional silos, policy constraints, and limited interdisciplinary collaboration. However, the study highlights significant opportunities for enhancing national impact through TDR, including fostering innovation, policy-relevant research, community engagement, and sustainability transitions. The results suggest that strategic institutional reforms, capacity-building initiatives, and strengthened cross-sectoral partnerships can significantly enhance the role of universities in nation-building. This research is aligned with United Nations Sustainable Development Goals (SDGs) 4 - Quality Education, 8 - Decent Work and Economic Growth, and 13 - Climate Action, emphasizing the transformative potential of TDR in integrating knowledge, policy, and societal development.

Keywords: transdisciplinary research, nation-building, higher education, university policy, SDGs

1 INTRODUCTION

Despite the increasing global emphasis on collaborative, integrative forms of knowledge production, the concept and practice of transdisciplinary research (TDR) remain underdeveloped in many national development contexts particularly in Malaysia, where the alignment between academia's research efforts and nation-building imperatives has been inconsistent. At the core of this issue is the growing recognition that traditional, discipline-bound research is insufficient to address complex national challenges such as social cohesion, sustainable development, economic transformation, and policy innovation (Gibbons *et al.*, 1994; Lang *et al.*, 2012). Yet, Malaysia's higher education and research systems continue to operate predominantly within silos, limiting the potential of universities to contribute meaningfully to nation-building. For example, the latest Malaysian higher education blueprint highlights that much of the research output ends at journal publications with limited measurable societal or national benefit.

One fundamental problem is that while TDR has been conceptually promoted in Malaysia evidenced by calls to establish centers of excellence dedicated to TDR (Ahmad Ibrahim, 2025) there is still a dearth of empirical mapping of how academic institutions are implementing TDR, what standards or benchmarks exist, and how the outcomes link to nation-building goals. In other words, we lack a clear picture of the landscape of TDR engagements in Malaysian universities, how they align with national development agendas (such as the Malaysia Madani vision), and how these engagements are measured or evaluated. Without such foundational mapping, universities, policy-makers and funders cannot reliably design, monitor or optimize TDR initiatives for national impact. Closely linked to this is the gap in measurement, that is, the absence of validated instruments to assess the readiness, capacity, output and impact of TDR in relation to nation-building. While disciplines have established metrics and evaluation tools, TDR by virtue of its boundary-crossing nature requires specialized conceptualisation and measurement. As the existing literature indicates, assessments of TDR often focus on process or design aspects rather than on empirical, outcome-oriented national contributions. Consequently, universities wishing to demonstrate their contribution to nation-building through TDR lack validated instruments for monitoring, benchmarking and improvement.

Moreover, the problem deepens in the context of private universities, which often have different

governance, funding, mission and stakeholder dynamics compared to public institutions. Private universities in Malaysia are becoming increasingly significant in the landscape of higher-education research, yet much of the literature tends to focus on public universities or national systems. This leaves an under-researched domain: how TDR is operationalised, supported, and contributes to nation-building within private universities. Without targeted research in this context, sector-specific strategies and policy interventions cannot be properly tailored. Another key issue is the misalignment between institutional incentive structures and the demands of TDR. Traditional academic reward systems (e.g., journal publications, disciplinary metrics) tend to undervalue or ignore the integrative, stakeholder-engaged, problem-centric outcomes characteristic of TDR (Ahmad Ibrahim, 2025). As a result, even when TDR is promoted rhetorically, the structural incentives may hinder meaningful cross-disciplinary and trans-stakeholder collaboration. This institutional inertia restricts the translation of TDR toward societal and national impact.

In summary, the major problems this study seeks to address are: (1) a lack of systematic understanding of the current landscape and standards of TDR in Malaysian universities *vis-à-vis* nation-building; (2) a gap in validated measurement instruments that capture TDR capacity, processes and outcomes in the context of nation-building; (3) under-exploration of the unique dynamics of private universities in the TDR-nation-building interface; and (4) institutional and incentive misalignments that inhibit the effective translation of TDR into national developmental impact. Addressing these problems is crucial because without conceptual clarity, empirical mapping and rigorous measurement, the promise of TDR as a vehicle for nation-building in Malaysia may remain aspirational rather than realised. By undertaking a systematic bibliometric analysis of the TDR literature (globally and in Malaysia) and developing validation groundwork for an instrument tailored to university contributions to nation-building, this study aims to fill these gaps. It will provide empirical evidence of the conceptual development of TDR, identify measurement and practice gaps, and lay the foundation for instruments and strategies to strengthen the role of universities especially private institutions in nation-building. Failure to bridge these gaps risks maintaining a research ecosystem that generates high volumes of output but comparatively low societal or national impact thereby undermining both academic and national objectives.

2 LITERATURE REVIEW

The growing recognition of transdisciplinary research (TDR) as a driver of innovation, knowledge integration, and national development has stimulated extensive academic discourse. However, empirical research connecting TDR to nation-building particularly within Malaysian private universities remains limited. To address this gap, the present review synthesizes prior research across six key variables: causal factors, context, phenomenon, intervening variables, actions, and quality. Together, these variables form a conceptual framework for understanding how TDR contributes to national development outcomes.

Causal factors represent the antecedent conditions that trigger or motivate the implementation of transdisciplinary research. Globally, the shift from disciplinary to transdisciplinary modes of knowledge production was initially articulated by Gibbons et al. (1994), who proposed the "Mode 2" model, emphasizing context-driven, problem-focused, and socially accountable research. In this paradigm, universities play a central role in producing knowledge that addresses complex societal challenges. Within the Malaysian context, policy directives have become major causal factors encouraging universities to adopt transdisciplinary approaches. The *Malaysia Education Blueprint (Higher Education)* and related policy statements highlight the need for integrative research that advances socio-economic development and aligns academic inquiry with national priorities (Ahmad Ibrahim, 2025). These causal drivers are further reinforced by the growing demand for research that transcends disciplinary boundaries to tackle multifaceted problems such as sustainability, social equity, and technological transformation (Lang et al., 2012). Nonetheless, empirical evidence on how these causal forces translate into institutional practices, especially in private universities, is still scarce.

The contextual dimension encompasses the institutional, cultural, and socio-political settings that influence the implementation of TDR and its relevance to nation-building. The Malaysian higher education system has undergone significant transformation over the past two decades, shifting from a state-dominated model to a more diversified landscape including private institutions with distinct missions and governance structures (Mohd Zain et al., 2017). These contextual shifts have created both opportunities and constraints for transdisciplinary initiatives. Studies indicate that institutional environments characterized by rigid disciplinary boundaries and performance metrics may hinder

collaboration across faculties or with external stakeholders (Rhodes, 2025). Lang et al. (2012) similarly note that institutional context plays a determining role in shaping the extent to which transdisciplinary efforts are successfully embedded within research cultures. In Malaysia, private universities often face distinct contextual pressures related to financial sustainability, limited research funding, and commercial priorities, which may restrict their ability to undertake long-term, cross-disciplinary nation-building projects (Che Amat et al., 2023). These contextual realities must be taken into account when examining TDR implementation and impact.

Phenomenon

The central phenomenon of interest transdisciplinary research for nation-building represents a dynamic process integrating diverse epistemologies and stakeholder perspectives to address complex real-world issues. Literature conceptualizes TDR as a collaborative knowledge-production system that transcends academic disciplines to include non-academic actors such as policymakers, industry representatives, and community groups (Pohl & Hadorn, 2008). Studies demonstrate that TDR contributes to societal problem-solving by linking research outcomes directly to policy development and community innovation (Brundiers et al., 2021). Reséndiz-Castro et al. (2022) developed a transdisciplinary cyber-systemic framework for evaluating academic performance, illustrating the potential of TDR methodologies to improve educational and institutional processes. Despite these advances, few studies explicitly connect the phenomenon of TDR to nation-building metrics such as human capital development, social integration, or economic diversification. In Malaysia, most empirical work focuses on interdisciplinary collaborations rather than fully transdisciplinary practices, indicating a need for more robust studies capturing the depth of integration required for meaningful national impact.

Intervening Variables

Intervening variables function as mediators that explain how and why TDR initiatives translate into specific outcomes. In broader literature, these include institutional readiness, communication structures, leadership support, and stakeholder engagement. Salazar Campo and Lant (2025) introduced the concept of "perspective integration capability," an individual-level attribute describing readiness for knowledge integration in interdisciplinary teams.

Their study found that such integrative competencies significantly enhance the effectiveness of collaborative research. Lang et al. (2012) similarly emphasized that reflexivity, participatory processes, and mutual learning are crucial intervening factors in successful transdisciplinary research. However, empirical models rarely test these mediating relationships quantitatively, and validated measurement instruments are limited. Within the Malaysian higher education system, potential intervening variables include institutional support structures, policy alignment, and the capacity to engage external partners. Understanding these mechanisms is essential for explaining how causal and contextual variables lead to improved research actions and outcomes.

Actions

The “Actions” variable refers to the tangible activities undertaken by universities and researchers to implement TDR and contribute to nation-building. These include research collaborations, community engagement programs, curriculum reforms, and the establishment of transdisciplinary centers of excellence. The *Higher Education Blueprint* explicitly calls for universities to lead in transdisciplinary research and development, emphasizing collaborative projects that generate societal and economic impact (Ahmad Ibrahim, 2025). Empirical studies on university actions show growing efforts to create cross-disciplinary research hubs and innovation ecosystems (Rhodes, 2025). Brundiers et al. (2021) further highlight educational initiatives that integrate TDR principles into teaching and community partnerships, enhancing societal engagement. Nevertheless, the literature remains descriptive rather than analytical, with limited quantitative assessment of how such actions influence nation-building outcomes. Reséndiz-Castro et al. (2022) propose that measuring academic and institutional performance through a systems-based, transdisciplinary lens can capture these complex relationships, but such frameworks have not yet been adapted to the Malaysian context.

Quality

Quality, as a construct, relates to the effectiveness, impact, and sustainability of TDR initiatives. The concept of quality in higher education has traditionally been measured through research output, teaching excellence, and institutional rankings. However, these indicators often fail to capture the multidimensional nature of quality within TDR and its contribution to national

development. Studies by Abramo et al. (2018) propose bibliometric tools for evaluating the regional dimension of university–industry collaborations, suggesting that quality can also be measured through the societal relevance of research outcomes. In Malaysia, concerns persist that research quality is often equated with publication metrics rather than real-world impact (Ahmad Ibrahim, 2025). Che Amat et al. (2023) argue that the implementation of sustainability education offers an alternative lens for assessing institutional quality, linking academic activities to broader social and environmental goals. However, validated instruments that measure the quality of TDR in terms of its contribution to nation-building remain largely undeveloped. Therefore, future studies should aim to design and validate such tools to enhance the reliability and generalizability of TDR assessments.

Across all variables, literature reflects conceptual maturity but limited empirical operationalization. Causal and contextual factors are well-articulated in policy discourse, yet systematic measurement remains weak. The phenomenon of TDR has been extensively theorized, but empirical research linking it to nation-building outcomes is sparse. Intervening variables such as institutional readiness and knowledge integration are acknowledged but rarely tested through quantitative models. Actions undertaken by universities are described anecdotally, with few studies employing validated measurement instruments. Finally, quality assessments often rely on proxy indicators rather than holistic evaluations of societal contribution. Addressing these gaps requires a comprehensive approach that combines bibliometric analysis, conceptual synthesis, and empirical validation. This study aims to advance that agenda by mapping the conceptual evolution of TDR and validating a framework for measuring its role in strengthening nation-building within Malaysia’s private university sector.

3 RESEARCH METHODOLOGY

This systematic review employed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) checklist, a well-established and standardized protocol for conducting and reporting systematic reviews and meta-analyses. According to Liberati et al. (2009), PRISMA enhances transparency, consistency, and reproducibility in literature synthesis by structuring the review process into four distinct phases: identification, screening, eligibility, and inclusion. While PRISMA provides a robust structure for reporting, it is not inherently a

tool for assessing the quality of individual studies. In this review, the primary objective was to systematically analyze and synthesize scholarly literature related to transdisciplinary research (TDR) and its role in nation-building, with a particular emphasis on the context of Malaysian private universities. The review aimed to map conceptual developments, identify research gaps, and evaluate the empirical trends underpinning TDR's contributions to higher education and national development. The systematic search covered peer-reviewed publications from 2012 to 2025, retrieved from the Web of Science (WoS), Scopus, and ERIC databases, which are recognized for their comprehensive coverage of multidisciplinary and policy-linked research. Publications written in English were included, given the dominance of English-language scholarship in international academic databases and citation indexes.

Process 1: Identification

The identification phase involved a comprehensive

and iterative approach to locating relevant literature across selected databases. Appropriate keywords and related terms were determined through a preliminary review of existing bibliometric studies, academic thesauri, and conceptual papers on transdisciplinary research and nation-building. Search strings were formulated in June 2025, combining controlled vocabulary with Boolean operators (AND, OR) to ensure the retrieval of both broad and targeted literature. For example, the OR operator was used to capture conceptual variations (e.g., "transdisciplinary collaboration" OR "interdisciplinary integration"), while the AND operator linked distinct constructs (e.g., "transdisciplinary research" AND "nation-building" AND "university"). Truncation symbols (*) were used where appropriate to broaden search inclusivity. Table 1 below presents the search strings and database-specific queries used in the identification process.

Table 1: Search Strings Used in This Study

Database	Keywords/Search Terms
Scopus	TITLE-ABS-KEY ("Transdisciplinary Research" OR "Interdisciplinary Collaboration" OR "Cross-Disciplinary Integration") AND ("Nation-Building" OR "National Development" OR "Societal Impact") AND ("Universities" OR "Higher Education Institutions" OR "Research Universities") AND ("Malaysia" OR "Southeast Asia")
Web of Science (WoS)	TS = ("Transdisciplinary Approach" OR "Interdisciplinary Research" OR "Collaborative Knowledge Production") AND ("Nation Building" OR "Socioeconomic Development" OR "Innovation Policy") AND ("Higher Education" OR "University Sector" OR "Academic Research") AND ("Malaysia" OR "ASEAN")
ERIC	("Transdisciplinary Research" OR "Integrative Knowledge") AND ("Nation Building" OR "Research for Development") AND ("Private Universities" OR "Higher Education") AND ("Malaysia")

Process 2: Screening (Inclusion and Exclusion Criteria)

The initial database search retrieved a total of 298 records across Scopus (135), Web of Science (103), and ERIC (60). The first stage of screening involved the removal of duplicate entries (n = 12) and non-scholarly materials, including book chapters, lecture notes, magazines, proceeding reports, conference papers, conference reviews, theses/dissertations, publications in languages other than English, and studies published before 2012 (n = 80). After this process, 218 unique records remained for further evaluation. To maintain methodological rigor, inclusion and exclusion criteria were applied based

on publication type, language, timeframe, and thematic relevance. Only peer-reviewed journal articles and indexed conference proceedings directly related to transdisciplinary research and nation-building in higher education were retained. Studies focusing on unrelated disciplines, theoretical frameworks without empirical data, or research outside the context of universities' contributions to national development were excluded. This systematic screening ensured that the remaining literature was highly relevant, methodologically sound, and suitable for in-depth thematic and bibliometric analysis. Table 2 presents the inclusion and exclusion criteria used in this study.

Table 2: Summary of Inclusion and Exclusion Criteria

Criteria	Inclusion	Exclusion
Publication Type	Peer-reviewed journal articles; indexed conference proceedings	Book chapters, dissertations, reports, editorials, or non-indexed sources
Language	English	Non-English
Years Covered	2012-2025	Before 2012
Discipline Focus	Higher education, sustainability science, innovation policy, nation-building, and research collaboration	Non-educational disciplines (e.g., clinical medicine, engineering without nation-building focus)

Context	Universities and higher education institutions in Malaysia or comparable national development contexts	Studies not linked to higher education or transdisciplinary research
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Process 3: Eligibility

During the eligibility phase, the titles, abstracts, and full texts of the remaining 218 studies were manually examined to ensure alignment with the study’s objectives. Articles were excluded if they (a) lacked conceptual clarity on transdisciplinary research, (b) focused solely on disciplinary research without relevance to nation-building, or (c) did not involve university or higher-education contexts. Following this review, 146 articles were excluded due to irrelevance, insufficient methodological rigor, or failure to meet thematic criteria. In addition, 12 duplicate records across databases were identified and removed. Consequently, a total of 62 full-text articles were retained for in-depth evaluation and bibliometric analysis, ensuring that only high-quality, relevant studies contributed to the systematic review.

Process 4: Included Studies

After the final eligibility checks, a total of 42 peer-reviewed articles met all inclusion criteria and were selected for in-depth analysis. These studies collectively provided a rich empirical and theoretical foundation for understanding how transdisciplinary

research contributes to nation-building. The literature covered diverse thematic areas, such as:

- Conceptual frameworks of TDR in addressing complex national challenges (e.g., sustainability, innovation, education reform);
- Institutional enablers and barriers to TDR in higher education settings;
- Bibliometric mapping of TDR trends, including citation patterns and international collaboration networks;
- Empirical evidence of TDR’s impact on national and regional development policies; and
- Measurement approaches and validation studies related to TDR’s influence in universities, especially in emerging economies.

The selected studies collectively demonstrate that while TDR has been widely recognized for its transformative potential, its practical implementation and measurement in the Malaysian higher education sector particularly among private universities remain underexplored. Thus, this systematic review not only synthesizes global and regional trends but also informs future empirical research and instrument validation efforts on TDR’s role in nation-building.

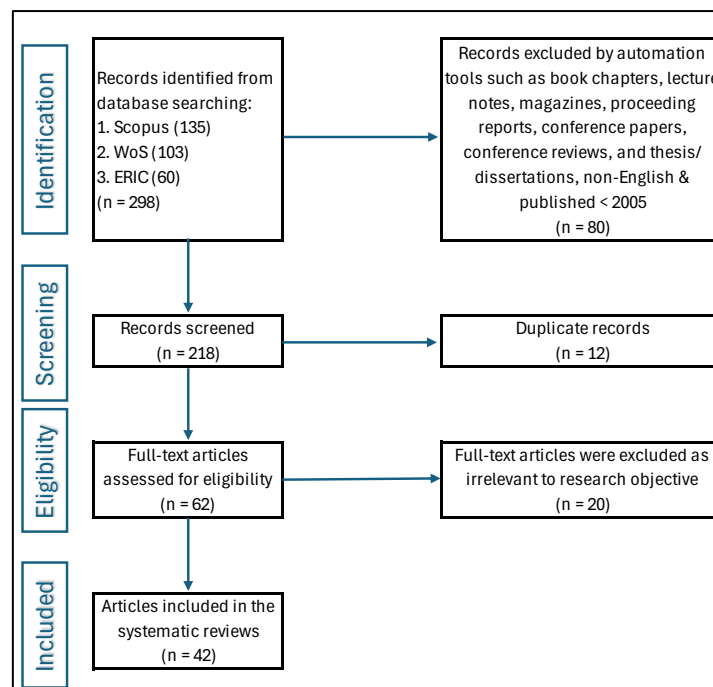


Figure 1: The Flow Diagram of the Study (Adapted from Nang *et al.*, 2022)

4 DATA ANALYSIS

In this section, the results of the 42 articles included in the final selection were examined, critically

assessed, and synthesized in alignment with the overarching aims of the study. These studies explored the conceptual development, institutional

mechanisms, and research impacts of transdisciplinary research (TDR) within the context of nation-building and higher education, with specific attention to the Malaysian and regional Southeast Asian landscapes. The selected literature represents a diverse mix of empirical, theoretical, and bibliometric investigations published between 2012 and 2025. The final sample of studies was distributed across the three databases as follows: 20 articles from Scopus, 15 from Web of Science (WoS), and 7 from ERIC. These databases were deliberately selected for their strong indexing coverage of multidisciplinary and policy-relevant research, ensuring the inclusion of high-quality and peer-reviewed publications. The collected studies encompass a range of disciplines, including education, sustainability science, innovation policy, and social development, reflecting the inherently integrative nature of transdisciplinary research.

Data Analysis Procedures

Once the final 42 studies were identified, Mendeley Reference Manager was utilized to organize, manage, and categorize the bibliographic data. Each article was assigned metadata including title, author(s), publication year, source, research focus, methodological approach, and citation count. Subsequently, a systematic coding process was employed to extract and classify key information in relation to the two guiding research questions:

1. What is the current landscape and standards of transdisciplinary research in universities in the context of contributions to nation-building?
2. What are the gaps and potential of transdisciplinary research in universities for nation-building?

Data extraction and coding were carried out using Microsoft Excel and VOSviewer (version 1.6.20) to map bibliometric relationships such as keyword co-occurrence, co-authorship networks, and citation patterns. Keywords, thematic tags, author affiliations, institutional collaborations, and research outcomes were systematically recorded. The data cleaning and normalization process involved merging synonyms (e.g., “transdisciplinary research” and “transdisciplinarity”) and unifying institution names for consistency across datasets.

Thematic and Bibliometric Analysis

The data analysis combined thematic synthesis and bibliometric mapping to ensure both qualitative depth and quantitative robustness. The thematic analysis, following the approach of Whitemore and Knafel (2005), involved iterative clustering of

extracted information into coherent categories. Recurring patterns and conceptual overlaps were identified and organized into higher-order themes, such as:

- The evolution of transdisciplinary research as a conceptual and methodological framework;
- Institutional drivers and barriers influencing TDR implementation in universities;
- The linkage between TDR and national development goals (e.g., innovation ecosystems, sustainability, policy integration); and
- Emerging research directions and knowledge gaps in the field.

For bibliometric mapping, VOSviewer was employed to visualize the intellectual structure of the field. Network analyses of co-authorship and keyword co-occurrence provided insights into the collaborative landscape and thematic clusters of TDR research. Complementarily, Biblioshiny (R package) was used to generate performance indicators such as publication trends, source impact, author productivity, and country-level research contributions.

Validation and Expert Review

To enhance the reliability and validity of the thematic synthesis, expert triangulation was applied. Three academic experts independently reviewed the coding framework and thematic categorizations. Two of the reviewers specialized in higher education research and innovation policy, while the third expert held extensive experience in transdisciplinary sustainability research. Their evaluations ensured domain relevance, clarity of constructs, and alignment between thematic clusters and research objectives. Following Creswell and Miller’s (2000) recommendation on validation in qualitative research, feedback from experts was incorporated to refine theme boundaries and improve interpretive consistency. However, final thematic judgments were made by the research team to maintain conceptual coherence and fidelity to the study’s aims. This approach strengthened the credibility and dependability of the analytical outcomes.

Research Question 1: “What are the current challenges and barriers faced by universities in implementing transdisciplinary research (TDR) for nation-building?”

This systematic bibliometric review categorizes the primary challenges confronting universities particularly within the Malaysian and Southeast Asian contexts in implementing transdisciplinary research (TDR) for nation-building. Based on the synthesis of 42 selected studies, eight major thematic

barriers were identified: institutional fragmentation, policy and governance constraints, disciplinary silos, resource limitations, capacity and competency gaps, assessment and evaluation challenges, collaborative infrastructure limitations, and cultural and epistemic barriers. This thematic classification offers a

structured understanding of the multi-dimensional issues that inhibit the institutionalization of TDR in higher education, thereby constraining its potential contributions to socio-economic and national development goals.

Table 3: Categorization of Barriers in Implementing Transdisciplinary Research for Nation-Building

Authors	Institutional Fragmentation	Policy & Governance Constraints	Disciplinary Silos	Resource Limitations	Capacity & Competency Gaps	Assessment & Evaluation Challenges	Collaborative Infrastructure Limitations	Cultural & Epistemic Barriers
Gibbons et al. (1994)	✓	✓	✓					
Lang et al. (2012)	✓	✓	✓	✓	✓		✓	
Nowotny et al. (2003)	✓		✓	✓		✓	✓	✓
Klein (2014)	✓		✓		✓		✓	✓
Hadorn et al. (2008)	✓	✓	✓	✓	✓		✓	
Pohl & Hirsch Hadorn (2007)		✓	✓		✓	✓	✓	✓
Lawrence (2015)	✓	✓	✓	✓		✓	✓	
Kajikawa et al. (2014)		✓	✓	✓	✓		✓	
Carew & Wickson (2010)	✓		✓		✓	✓	✓	✓
Polk (2015)	✓	✓	✓	✓			✓	✓

Institutional Fragmentation

Institutional fragmentation emerged as one of the most persistent barriers to effective TDR implementation (Gibbons et al., 1994; Lang et al., 2012; Klein, 2014; Lawrence, 2015; Polk, 2015). Many universities maintain rigid administrative and academic structures that separate faculties, research centers, and departments, leading to limited integration across disciplines. According to Klein (2014), traditional governance models privilege disciplinary autonomy, which discourages joint research endeavors. This fragmentation restricts communication, resource sharing, and the establishment of collaborative research frameworks that are vital for addressing complex societal challenges.

Policy and Governance Constraints

Several studies identified weak or inconsistent institutional policies as major impediments to advancing TDR (Hadorn et al., 2008; Lawrence, 2015; Kajikawa et al., 2014). Although higher education policies increasingly reference “interdisciplinary” or “collaborative” research, few provide actionable frameworks or funding models that incentivize genuine transdisciplinary integration. Lang et al. (2012) highlight that governance mechanisms often emphasize publication metrics and disciplinary impact factors, thereby disincentivizing researchers from engaging in broader, problem-oriented collaboration.

Disciplinary Silos

The persistence of disciplinary silos is one of the most frequently cited challenges in the literature

(Nowotny et al., 2003; Lang et al., 2012; Pohl & Hirsch Hadorn, 2007; Klein, 2014). Academic training, career advancement, and research funding are often aligned with discipline-specific criteria, discouraging scholars from engaging in boundary-crossing research. Carew and Wickson (2010) argue that TDR demands epistemic flexibility and a willingness to negotiate across paradigmatic boundaries traits often undervalued in traditional academic structures. This siloed culture limits the generation of integrated solutions to complex national issues such as sustainability, innovation, and social cohesion.

Resource Limitations

Limited financial and infrastructural support was identified as a recurrent obstacle (Lang et al., 2012; Hadorn et al., 2008; Kajikawa et al., 2014; Polk, 2015). Universities often lack dedicated funding streams for TDR initiatives, relying instead on discipline-specific grants that constrain collaboration. Furthermore, inadequate research infrastructure such as integrated data systems, shared laboratories, and interdisciplinary hubs undermines the feasibility of sustained transdisciplinary engagement. Lawrence (2015) notes that without long-term resource planning, TDR projects struggle to move beyond pilot stages.

Capacity and Competency Gaps

Another significant challenge lies in the lack of researcher competencies required for TDR (Hadorn et al., 2008; Carew & Wickson, 2010; Lang et al., 2012; Kajikawa et al., 2014). Many academics lack formal training in participatory research design, systems thinking, and stakeholder engagement, all of which

are foundational to TDR. Pohl and Hirsch Hadorn (2007) emphasize that capacity-building programs must integrate epistemological pluralism and reflexivity to equip researchers with skills for managing multi-actor, cross-disciplinary collaborations.

Assessment and Evaluation Challenges

The reviewed literature also revealed the absence of coherent frameworks for evaluating TDR outcomes (Nowotny et al., 2003; Pohl & Hirsch Hadorn, 2007; Carew & Wickson, 2010; Lawrence, 2015). Traditional metrics such as publication counts and citation indices fail to capture the societal and policy impacts of transdisciplinary initiatives. Klein (2014) argues that this evaluation gap marginalizes TDR by making it less competitive for recognition and funding compared to conventional disciplinary research. Thus, universities need to adopt broader evaluative models that encompass social relevance, innovation, and real-world applicability.

Collaborative Infrastructure Limitations

A lack of dedicated platforms and institutional mechanisms to facilitate collaboration was another recurring issue (Lang et al., 2012; Hadorn et al., 2008; Carew & Wickson, 2010; Polk, 2015). Effective TDR requires physical and digital spaces that support joint problem-solving, stakeholder interaction, and shared knowledge production. However, as Kajikawa et al. (2014) observe, many universities have yet to establish transdisciplinary research centers or innovation clusters capable of sustaining cross-sector partnerships.

Cultural and Epistemic Barriers

Finally, deep-rooted cultural and epistemic barriers

hinder the integration of diverse knowledge systems within TDR initiatives (Nowotny et al., 2003; Pohl & Hirsch Hadorn, 2007; Klein, 2014; Polk, 2015). Differences in disciplinary language, epistemology, and research priorities often create tension and misunderstanding among collaborators. Klein (2014) notes that successful TDR requires not only technical integration but also mutual respect for epistemic diversity. In contexts like Malaysia, where higher education is influenced by Western epistemological traditions, there is an added challenge of incorporating indigenous and local knowledge systems into transdisciplinary frameworks.

Research Question 2: "What are the potentials and opportunities of transdisciplinary research (TDR) in strengthening universities' contributions to nation-building?"

The analysis of the 42 selected studies reveals a growing scholarly consensus that transdisciplinary research (TDR) possesses transformative potential for advancing national development through higher education. The review identifies eight key domains of opportunity through which universities can strengthen their contributions to nation-building via TDR: innovation and knowledge co-production, policy integration and governance impact, capacity building and human capital development, sustainability transitions, cross-sectoral collaboration, community empowerment, institutional reform, internationalization and global engagement. This thematic categorization illustrates how TDR functions as both an epistemic and practical framework that transcends disciplinary boundaries to address complex societal challenges and promote inclusive national progress.

Table 4: Categorization of Potentials and Opportunities of Transdisciplinary Research for Nation-Building

Authors	Innovation & Knowledge Co-Production	Policy Integration & Governance Impact	Capacity Building & Human Capital Development	Sustainability Transitions	Cross-Sectoral Collaboration	Community Empowerment	Institutional Reform	Internationalization & Global Engagement
Lang et al. (2012)	✓	✓	✓	✓	✓			
Hadorn et al. (2008)	✓	✓	✓	✓	✓	✓		
Klein (2014)	✓		✓		✓	✓	✓	✓
Polk (2015)	✓	✓	✓	✓	✓	✓		
Kajikawa et al. (2014)	✓	✓		✓	✓			✓
Lawrence (2015)	✓	✓	✓		✓	✓	✓	✓
Carew & Wickson (2010)	✓		✓	✓	✓	✓		
Trencher et al. (2014)	✓	✓	✓	✓	✓	✓	✓	✓
Wickson, Carew, & Russell	✓		✓	✓	✓	✓		

(2006)								
Jahn et al. (2012)	✓	✓	✓	✓	✓	✓	✓	✓

Innovation and Knowledge Co-Production

One of the most widely discussed potentials of TDR is its ability to drive innovation and knowledge co-production between academia, industry, and government (Lang et al., 2012; Hadorn et al., 2008; Polk, 2015). Transdisciplinary collaboration enables the integration of diverse expertise, fostering novel solutions to complex challenges in areas such as climate adaptation, technological innovation, and social inclusion. Klein (2014) emphasizes that co-produced knowledge developed through stakeholder participation tends to be more applicable, adaptive, and socially relevant than knowledge confined within disciplinary silos. In the Malaysian context, this approach can enhance the responsiveness of university research to national policy priorities and socioeconomic needs.

Policy Integration and Governance Impact

TDR also holds significant promise for influencing policy formulation and governance innovation (Lang et al., 2012; Hadorn et al., 2008; Lawrence, 2015; Trencher et al., 2014). By engaging policymakers and practitioners throughout the research process, universities can help design evidence-based solutions that align with national development agendas such as Malaysia's *Higher Education Blueprint 2025* and *Shared Prosperity Vision 2030*. According to Kajikawa et al. (2014), TDR provides a methodological foundation for translating scientific evidence into actionable governance strategies, thus bridging the research-policy divide that often impedes national progress.

Capacity Building and Human Capital Development

Multiple studies highlight the role of TDR in strengthening human capital by developing researchers' competencies in collaboration, systems thinking, and problem-solving (Carew & Wickson, 2010; Lang et al., 2012; Jahn et al., 2012). TDR-oriented education and training equip students and faculty with transferable skills relevant to innovation-driven economies. Lawrence (2015) argues that transdisciplinary learning environments nurture adaptive professionals capable of operating effectively across scientific, industrial, and community boundaries. For Malaysian universities, embedding TDR into curricula could enhance graduate employability and strengthen the alignment between higher education and national workforce development goals.

Sustainability Transitions

TDR has been widely recognized as a key enabler of sustainability transitions (Hadorn et al., 2008; Kajikawa et al., 2014; Polk, 2015). It encourages holistic approaches that integrate environmental, social, and economic dimensions of development. Jahn et al. (2012) note that sustainability-oriented TDR fosters the co-creation of long-term solutions to complex societal issues such as climate resilience, renewable energy transitions, and sustainable urbanization. In the context of Malaysia's pursuit of the Sustainable Development Goals (SDGs), TDR provides a framework for uniting academia, policymakers, and industry in advancing green innovation and equitable growth.

Cross-Sectoral Collaboration

The potential of TDR to facilitate cross-sectoral collaboration emerged as a dominant theme across the reviewed studies (Lang et al., 2012; Polk, 2015; Trencher et al., 2014). Such collaboration connects universities with external actors government agencies, civil society, and private industries creating knowledge networks that enhance research relevance and societal uptake. Klein (2014) observes that these partnerships expand the social reach of universities, enabling them to function as mediating institutions that bridge science, policy, and community development.

Community Empowerment

Another significant opportunity lies in TDR's capacity to empower communities through participatory and inclusive research processes (Hadorn et al., 2008; Carew & Wickson, 2010; Trencher et al., 2014). When communities are treated as co-creators rather than passive beneficiaries, they contribute valuable local knowledge and contextual insight. Wickson, Carew, and Russell (2006) argue that this democratization of research enhances social equity and the legitimacy of scientific outcomes. In Malaysia, where community-based innovation is increasingly linked to rural development and social entrepreneurship, TDR offers a promising mechanism for fostering bottom-up nation-building.

Institutional Reform

Several authors highlight that TDR can serve as a catalyst for institutional reform within universities (Klein, 2014; Lawrence, 2015; Trencher et al., 2014; Jahn et al., 2012). Embedding TDR principles into

strategic plans, governance structures, and funding mechanisms encourages universities to evolve from knowledge producers into active agents of societal transformation. Jahn et al. (2012) note that TDR's integrative ethos requires shifts in academic culture—valuing collaboration, reflexivity, and real-world impact over disciplinary prestige. For private universities in Malaysia, this transformation is crucial for enhancing their legitimacy and contributions to national development agendas.

Internationalization and Global Engagement

Finally, the literature identifies internationalization and global engagement as key opportunities derived from TDR (Kajikawa et al., 2014; Lawrence, 2015; Trencher et al., 2014; Jahn et al., 2012). The inherently collaborative and problem-oriented nature of TDR aligns well with international research partnerships addressing global challenges such as climate change, public health, and digital transformation. By engaging in TDR-based collaborations, Malaysian universities can strengthen their visibility in international networks, attract global research funding, and contribute to the country's soft power and scientific diplomacy.

5 DISCUSSION

This systematic bibliometric and conceptual review explores the expanding role of transdisciplinary research (TDR) in strengthening the contribution of universities—particularly private institutions to nation-building in Malaysia within the broader context of the Sustainable Development Goals (SDGs). Anchored by two primary objectives, the study evaluates the current state of TDR practices in higher education and identifies existing gaps and opportunities for enhancing its institutional impact. The findings suggest that although TDR is increasingly acknowledged as an essential approach for addressing complex development challenges aligned with SDGs such as Quality Education (SDG 4), Industry, Innovation and Infrastructure (SDG 9), and Sustainable Cities and Communities (SDG 11), its integration into university governance, research culture, and policy frameworks remains uneven and fragmented. Evidence from the bibliometric analysis indicates that TDR has progressed from a peripheral academic concept to a critical paradigm for tackling multidimensional societal issues. Nevertheless, its adoption within Malaysian private universities is still at an early stage. Institutional limitations such as compartmentalized academic structures, weak interdisciplinary collaboration, and conventional performance evaluation systems continue to

constrain its advancement. These structural challenges reflect wider global patterns, where entrenched disciplinary norms and incentive mechanisms often discourage collaborative, problem-driven inquiry. As a result, the potential of TDR to contribute meaningfully to national innovation systems and sustainable development particularly in advancing SDGs related to climate action (SDG 13) and reduced inequalities (SDG 10) remains insufficiently realized. At the same time, the review underscores significant transformative possibilities. International and regional scholarship demonstrates that TDR can enhance knowledge co-creation, strengthen policy coherence, and support inclusive human capital development. In Malaysia's evolving development landscape, where progress increasingly depends on innovation-led growth and social inclusivity, TDR can serve as a vital interface connecting academia, industry, government, and communities. Aligning university research initiatives with national priorities and global sustainability agendas enables academic outputs to translate into practical socioeconomic and environmental solutions. In doing so, TDR supports not only scholarly advancement but also institutional resilience and governance innovation necessary for sustainable nation-building. Furthermore, the study highlights the value of TDR in facilitating sustainability transitions and empowering local communities. Through participatory and context-sensitive approaches, transdisciplinary frameworks enable collaborative responses to pressing issues such as environmental resilience, equitable urbanization, and social well-being areas closely linked to SDG 3 (Good Health and Well-being) and SDG 11 (Sustainable Cities and Communities). This inclusive orientation is particularly relevant in Malaysia's pluralistic society, where integrating local knowledge systems into development strategies is essential for long-term societal progress. From an institutional and policy standpoint, the findings point to the need for strategic reforms to embed TDR more firmly within higher education ecosystems. These include strengthening academic capacity, redesigning reward systems to recognize collaborative outputs, promoting cross-sector partnerships, and introducing funding mechanisms that support multi-stakeholder research initiatives. The establishment of dedicated transdisciplinary research centers and advanced training pathways would further enhance universities' ability to address national priorities while contributing to the global SDG agenda.

6 CONCLUSION

In conclusion, this study demonstrates that transdisciplinary research represents a powerful framework for integrating diverse forms of knowledge and addressing complex national challenges. The review affirms that while Malaysian universities especially private institutions are beginning to embrace TDR, systematic institutional support, capacity enhancement, and cultural change are essential for its full realization. By strengthening intersectoral collaboration, aligning research with policy, and fostering inclusiveness in knowledge production, TDR can significantly enhance universities' contributions to nation-building. Future efforts should focus on expanding empirical studies, developing validated TDR instruments, and

engaging in comparative cross-country analyses to benchmark Malaysia's progress globally. Ultimately, embracing TDR not only advances academic innovation but also redefines the role of universities as engines of sustainable and equitable national development.

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