



The Role of Multidisciplinary Research in Solving Complex Global Problems

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Abstract

Background: Complex global problems such as climate change, pandemics, energy crises, and social inequalities require integrated solutions that transcend traditional disciplinary boundaries. Multidisciplinary research has emerged as a critical approach for addressing these interconnected challenges through collaborative knowledge integration.

Objective: This study examines the role of multidisciplinary research in solving complex global problems, analyzing successful applications, implementation challenges, and factors that determine collaborative effectiveness across diverse domains.

Methods: A comprehensive literature review was conducted examining multidisciplinary research applications in climate change, health crises, energy sustainability, and social inequality. Sources included peer-reviewed articles, case studies, institutional reports, and policy documents published between 2000-2025, with particular emphasis on recent developments.

Results: Multidisciplinary research demonstrates significant effectiveness in addressing global challenges through integrated approaches that combine technical expertise, social understanding, and policy insights. Successful applications include climate change mitigation strategies, pandemic preparedness systems, energy transition frameworks, and poverty reduction initiatives. However, persistent barriers include communication difficulties, institutional constraints, funding challenges, and coordination complexities.

Conclusion: Multidisciplinary research plays an essential role in solving complex global problems by enabling comprehensive understanding, integrated solutions, and transformative innovations. Success requires strategic attention to collaboration frameworks, institutional support, and barrier mitigation strategies.

Keywords: multidisciplinary research, global challenges, climate change, pandemic response, energy crisis, social inequality, interdisciplinary collaboration, complex systems

Introduction

The twenty-first century is characterized by an unprecedented array of interconnected global challenges that defy conventional problem-solving approaches. Climate change threatens ecological stability and human well-being across multiple scales, recent pandemics have demonstrated the vulnerability of global health systems, energy security concerns challenge sustainable development, and persistent social inequalities undermine societal cohesion. These complex problems share common characteristics: they are multifaceted, interconnected, and transcend traditional disciplinary boundaries, making them inherently unsuitable for single-discipline solutions. ^{[1] [2] [3] [4] [5] [6]}

The recognition that contemporary global challenges require integrated approaches has catalyzed the emergence of multidisciplinary research as a fundamental framework for addressing complex problems. Multidisciplinary research, defined as collaborative investigation that integrates knowledge, methods, and perspectives from multiple academic disciplines, offers unique capabilities for comprehensive understanding and holistic problem-solving. This approach acknowledges that real-world problems are inherently complex systems that require diverse expertise, methodologies, and perspectives to understand and

address effectively.^{[2][3][7][1]}

The Imperative for Multidisciplinary Approaches stems from the interconnected nature of global challenges that cannot be adequately addressed within the confines of individual disciplines. Climate change, for instance, involves atmospheric sciences, economics, policy studies, social sciences, and engineering, requiring integration across these domains to develop effective mitigation and adaptation strategies. Similarly, pandemic preparedness necessitates collaboration between epidemiology, public health, economics, behavioral sciences, and governance studies to create robust response systems.^{[8][3][9][4][10][11][1][2]}

Historical Context and Evolution reveal that multidisciplinary research has evolved from recognizing the limitations of disciplinary silos to actively promoting collaborative approaches for complex problem-solving. Early examples of successful multidisciplinary work, such as the Manhattan Project and space exploration programs, demonstrated the power of integrated expertise for achieving ambitious objectives. More recently, global initiatives addressing climate change, health crises, and sustainable development have increasingly adopted multidisciplinary frameworks.^{[10][12][13][14][1]}

Globalization and Complexity have intensified the need for multidisciplinary approaches by creating interconnected systems where local and global issues are intertwined. The COVID-19 pandemic exemplified this interconnectedness, demonstrating how health, economic, social, and political dimensions interact in complex ways that require integrated understanding and coordinated responses. Similarly, climate change manifests through environmental, economic, social, and political channels that necessitate comprehensive approaches.^{[3][4][11][1][2][8][10]}

Research Integration Challenges highlight the complexity of conducting effective multidisciplinary research while maintaining scientific rigor and practical relevance. Traditional academic structures, funding mechanisms, and evaluation criteria often favor disciplinary specialization, creating barriers to collaborative approaches. However, growing recognition of multidisciplinary value is driving institutional changes and new frameworks for collaborative research.^{[15][7][14][16][17]}

The urgency of addressing complex global problems within critical timeframes has intensified focus on research approaches that can deliver rapid, scalable, and effective solutions. This context creates both opportunity and pressure for multidisciplinary research to demonstrate its capacity for generating transformative innovations and practical solutions to humanity's most pressing challenges.^{[18][1][3]}

Materials and Methods

This study employed a comprehensive systematic literature review methodology to examine the role of multidisciplinary research in addressing complex global problems. The research design incorporated analysis of peer-reviewed articles, institutional reports, case studies, and policy documents spanning the period from 2000 to 2025, with particular emphasis on developments since 2020.

Search Strategy: Multiple academic databases, institutional repositories, and policy sources were systematically searched including PubMed, Web of Science, Google Scholar, and specialized databases for climate research, health policy, energy studies, and development research. Primary search terms included combinations of "multidisciplinary research,"

"interdisciplinary collaboration," "global challenges," "climate change solutions," "pandemic response," "energy crisis," "social inequality," and "complex problems." Additional targeted searches examined specific applications and case studies in each problem domain.

Inclusion Criteria: Sources were selected based on: (1) focus on multidisciplinary or interdisciplinary approaches to global challenges; (2) examination of real-world applications, case studies, or empirical evidence; (3) relevance to climate change, health crises, energy sustainability, or social inequality; (4) publication in credible academic venues or reputable institutional sources; (5) sufficient methodological detail or analytical depth; and (6) availability in English language.

Problem Domain Framework: Four major categories of global challenges were identified for detailed analysis: (1) Climate Change and Environmental Degradation; (2) Global Health Crises and Pandemics; (3) Energy Security and Sustainability Transitions; and (4) Poverty and Social Inequality. Each domain was analyzed for multidisciplinary research applications, successful interventions, and collaborative frameworks.

Analytical Approach: Sources were systematically analyzed using thematic analysis to identify patterns in multidisciplinary applications, success factors, implementation challenges, and outcomes. Content was categorized into six primary themes: successful applications in each problem domain, implementation challenges and barriers, and success factors for effective collaboration. Cross-domain analysis identified common patterns and unique characteristics across different types of global challenges.

Case Study Selection: Particular attention was given to documented case studies that demonstrated successful multidisciplinary collaboration in addressing specific global challenges. Cases were selected to represent diverse geographical contexts, collaborative structures, and problem types while providing sufficient detail for meaningful analysis of collaborative processes and outcomes.

Results

Climate Change Solutions Through Multidisciplinary Research

Multidisciplinary research has proven essential for addressing climate change through integrated approaches that combine technical, social, economic, and policy dimensions.

Interdisciplinary Climate Frameworks demonstrate sophisticated integration of atmospheric sciences, economics, social sciences, and engineering to develop comprehensive understanding of climate systems and solution pathways. The recognition that climate change is not solely an environmental problem but a multifaceted challenge interwoven with social, economic, and political systems has driven adoption of collaborative approaches.^{[9][2][10]}

MIT's interdisciplinary approach to climate research exemplifies effective multidisciplinary collaboration, with Principal Research Scientist Audun Botterud tackling cross-cutting problems from energy market interactions to battery design. This approach integrates electrical engineering, economics, and policy analysis to address complex energy system challenges related to climate mitigation. The work demonstrates how multidisciplinary perspectives enable comprehensive solutions that account for technical feasibility, economic viability, and policy implementation.^[19]

Rethinking Interdisciplinarity in climate research has become necessary as growing political pressure to find solutions leads to increasing calls for multiple disciplines to contribute knowledge systems that offer deeper and broader insights. However, most interdisciplinary approaches fail to adequately merge framings from disparate disciplines, resulting in reductionist messages largely devoid of context. Effective climate research requires accepting plurality of narratives, embracing multiple disciplinary perspectives, and integrating appropriate disciplines that understand human systems to better mediate action.^[10]

Multi-scale Integration characterizes successful climate research that operates across temporal and spatial scales, from local adaptation strategies to global mitigation policies. Multidisciplinary approaches enable synthesis of ideas from vast sets of disciplines including science, engineering, social science, and humanities to address complex environmental problems. Training programs and workshops are providing opportunities for scientists to learn collaborative work in multidisciplinary teams addressing climate change challenges.^{[9][10]}

Pandemic Preparedness and Health Crisis Response

The COVID-19 pandemic has provided unprecedented examples of multidisciplinary research applications in health crisis response, demonstrating both the potential and challenges of collaborative approaches. **Data-Driven Cross-Disciplinary Collaboration** at the FMUSP-HC academic health system implemented innovative management routines for collecting, organizing, and analyzing data from over 4,500 COVID-19 patients, establishing multidisciplinary taskforces and biobanking facilities. This comprehensive approach involved joint institutional efforts across disciplines focusing on cooperation, equity, and transparency.^{[4][11][8]}

Multidisciplinary Research Applications during the pandemic included genome sequencing combining immunology, virology, and vaccinology; developing impact measurement tools through epidemiology, statistics, public health, and data science; rapidly implementing technologies like telemedicine through digital health, engineering, and operations management; and assessing economic impacts through political science, economics, and public health. These examples demonstrate how health emergencies require integration across biomedical, technological, social, and economic domains.^[4]

Cross-Disciplinary Pandemic Solutions recognize that broader public health challenges require decision-makers to adopt multidisciplinary, cross-disciplinary, and transdisciplinary collaborative approaches. Pandemic preparedness involves multitasking challenges that need integrated solutions spanning medical sciences, public health, social sciences, economics, and governance. Effective pandemic response requires collaborative knowledge production between academic and non-academic stakeholders.^[11]

Global Health Initiative Coordination demonstrates sophisticated multidisciplinary approaches to health system strengthening. Global Health Initiatives integrate efforts of stakeholders worldwide to mobilize and disburse funds for addressing health challenges, supporting implementation of health programs in low- and middle-income countries. These initiatives exemplify multisectoral collaboration involving governments, international organizations, research institutions, and civil society.^{[12][20][13]}

Energy Crisis and Sustainability Transitions

Multidisciplinary research plays a critical role in addressing energy crises through integrated approaches that combine technical innovation, policy development, and social implementation. **Energy Transition Strategies** require sophisticated integration of engineering, economics, policy studies, and social sciences to develop comprehensive solutions. Modern technologies including artificial intelligence and Internet of Things provide means to alleviate energy crises, with multidisciplinary approaches essential for developing and implementing these innovations.^{[21][6][22][23]}

Renewable Energy Innovation demonstrates successful multidisciplinary collaboration in developing sustainable energy solutions. NUS research into renewable energy sources, energy storage, and efficient energy use exemplifies multidisciplinary approaches combining materials science, engineering, economics, and policy studies. This integration enables comprehensive understanding of technical possibilities, economic viability, and implementation pathways.^{[6][23]}

Policy and Technology Integration characterizes successful energy transition initiatives that combine technical innovation with policy frameworks and social acceptance. India's approach to addressing power crisis involves multi-pronged strategies encompassing both short-term and long-term solutions, including renewable energy investment, infrastructure modernization, policy reform, and energy conservation. These comprehensive approaches demonstrate the necessity of multidisciplinary integration for effective energy transitions.^{[24][21]}

Global Energy Research Coordination involves complex systems thinking that integrates technical, economic, social, and environmental dimensions. Research initiatives demonstrate that 10-40% of energy consumption can be reduced through renewable energy sources, passive design strategies, smart grid analytics, and intelligent energy monitoring, requiring integration across multiple disciplines. Artificial intelligence shows potential for 18.97-42.60% energy consumption reduction in buildings through deep neural networking applications.^{[23][6]}

Social Inequality and Poverty Reduction

Multidisciplinary research has proven essential for understanding and addressing complex issues of poverty and social inequality that transcend traditional disciplinary boundaries. **Cross-Disciplinary Poverty Research** recognizes that poverty issues remain fragmented despite arguments for multidisciplinary approaches, with intellectual barriers between economics and other social sciences continuing to impede comprehensive understanding. Effective poverty research requires integration of economic analysis with insights from anthropology, sociology, political science, and other social sciences.^{[5][25][26][27]}

Development Studies Integration exemplifies successful multidisciplinary approaches to complex social problems. Cross-disciplinary research promotes comprehensive understanding by bringing together researchers from diverse disciplines to investigate poverty, inequality, and well-being through integrated methodologies. This approach enables more holistic understanding of complex social phenomena that cannot be adequately captured through single-discipline perspectives.^{[26][27][5]}

Multi-Dimensional Approaches to poverty and inequality research demonstrate the value of integrating quantitative and

qualitative methods across disciplines. Collaborative research enables understanding of economic, social, cultural, and political dimensions of inequality through sophisticated analytical frameworks that combine diverse methodological approaches. These approaches generate more comprehensive insights into causes and potential solutions for persistent social problems.^{[27][28][5]}

Policy-Research Interface Development represents critical applications of multidisciplinary research to governance and policy challenges. The J-PAL Governance Initiative demonstrates how multidisciplinary collaborations can spark innovative solutions for complex governance challenges, bringing together economics, psychology, behavioral science, and policy studies to address questions of accountability, service delivery, and corruption. Research demonstrates that interdisciplinary work attracts greater attention from policy documents, indicating higher potential for policy impact.^{[16][5][18]}

Discussion

The analysis reveals that multidisciplinary research plays an indispensable role in addressing complex global problems by providing capabilities for comprehensive understanding, integrated solution development, and transformative innovation that transcend the limitations of single-discipline approaches. The evidence demonstrates consistent patterns of success across diverse problem domains when collaborative approaches effectively integrate diverse expertise, methodologies, and perspectives.^{[7][1][2][8][3][5][6]}

Transformative Problem-Solving Capabilities emerge as a defining characteristic of successful multidisciplinary research applications. The COVID-19 pandemic response exemplified this capacity, with collaborative approaches enabling rapid development of vaccines, implementation of public health measures, economic support systems, and social adaptation strategies through unprecedented coordination across disciplines. Similarly, climate change research demonstrates how integration of natural sciences, social sciences, and policy studies generates comprehensive understanding and solution pathways impossible through individual disciplines.^{[1][2][8][11][7][9][4][10]}

Systems-Level Understanding represents a critical advantage of multidisciplinary approaches that enable researchers to comprehend complex interactions and feedback loops across different domains. Energy transition research demonstrates this capacity through integration of technical innovation, economic analysis, policy development, and social acceptance studies to create comprehensive transformation strategies. This systems perspective enables identification of synergies, trade-offs, and unintended consequences that might be missed by narrower disciplinary approaches.^{[3][5][6][23][24][1]}

Innovation Through Integration occurs when diverse knowledge domains interact to generate novel insights, methodologies, and solutions. The intersection of artificial intelligence, sustainability science, and policy studies demonstrates this potential through development of smart energy systems that integrate technical capabilities with behavioral insights and regulatory frameworks. Similarly, global health initiatives exemplify innovation through integration of medical science, economics, governance, and implementation science.^{[20][13][29][19][12][6][18][7]}

Barriers and Implementation Challenges remain significant obstacles to realizing the full potential of

multidisciplinary research. Communication barriers arising from disciplinary jargon, methodological differences, and conceptual frameworks create substantial challenges for effective collaboration. Institutional structures that organize research by disciplinary departments create barriers to promotion, recognition, and career development for interdisciplinary researchers. Funding mechanisms often favor single-discipline projects, limiting resources available for collaborative initiatives.^{[14][30][17][31][15]}

Success Factors and Best Practices emerge from analysis of effective multidisciplinary collaborations across different domains. Clear communication protocols, shared governance structures, and common objectives facilitate effective collaboration. Strong leadership that can navigate disciplinary differences while maintaining project focus proves essential for success. Institutional support through appropriate evaluation criteria, shared facilities, and administrative structures enables sustainable collaborative research.^{[32][8][7][14][16]}

Policy Integration and Impact represents a critical dimension where multidisciplinary research demonstrates particular value. Research with higher interdisciplinarity attracts greater attention from policy documents, indicating enhanced potential for practical impact. The variety dimension of interdisciplinarity exhibits the most pronounced positive impact on political attention, suggesting that policymakers value research that draws from diverse disciplinary sources. This finding highlights the importance of multidisciplinary research for translating scientific knowledge into policy outcomes.^{[18][16][10]}

Future Directions and Emerging Trends suggest continued evolution toward more sophisticated collaborative approaches that leverage technology, engage stakeholders, and address complex system interactions. The future of research lies in dynamic intersections of varied fields where fusion of diverse expertise ignites innovation and drives significant breakthroughs. Digital technologies and artificial intelligence create new opportunities for collaboration, data integration, and solution development while also presenting their own multidisciplinary challenges.^{[29][33][34][6]}

Institutional Transformation Requirements become increasingly apparent as traditional academic structures struggle to accommodate innovative collaborative approaches. Universities and funding agencies must develop new frameworks for evaluating, supporting, and rewarding multidisciplinary research while maintaining standards of scientific rigor. This transformation requires changes in academic culture, career pathways, and institutional organization to fully support collaborative approaches.^{[17][29][14][16]}

Conclusion

This comprehensive analysis demonstrates that multidisciplinary research plays an essential and increasingly critical role in solving complex global problems through its unique capacity for comprehensive understanding, integrated solution development, and transformative innovation. The evidence across climate change, pandemic response, energy transitions, and social inequality clearly establishes that the most pressing challenges of our time require collaborative approaches that transcend traditional disciplinary boundaries to generate effective solutions.

The success of multidisciplinary research in addressing global challenges stems from its ability to integrate diverse

knowledge systems, methodologies, and perspectives to create holistic understanding of complex phenomena. Climate change research exemplifies this capacity through sophisticated integration of natural sciences, social sciences, economics, and policy studies to develop comprehensive mitigation and adaptation strategies. Similarly, pandemic preparedness demonstrates the power of collaborative approaches that combine medical sciences, public health, behavioral sciences, and governance to create robust response systems.

However, significant barriers continue to impede the full realization of multidisciplinary potential, including persistent communication challenges, institutional constraints that favor disciplinary specialization, funding mechanisms inadequately designed for collaborative research, and coordination difficulties inherent in managing diverse teams. Overcoming these barriers requires strategic interventions including development of clear communication protocols, institutional reforms that support collaborative career paths, flexible funding mechanisms that accommodate interdisciplinary projects, and leadership development for managing complex collaborative initiatives.

The analysis reveals consistent success factors across different domains: effective communication that bridges disciplinary differences, strong leadership that can navigate complexity while maintaining focus, institutional support that provides appropriate evaluation and recognition systems, and stakeholder engagement that ensures practical relevance and implementation capacity. These factors provide a framework for optimizing multidisciplinary research approaches to maximize impact on global challenges.

Looking toward the future, multidisciplinary research will become increasingly important as global challenges grow more complex and interconnected. The integration of digital technologies, artificial intelligence, and sophisticated analytical tools creates new opportunities for collaborative research while requiring new forms of multidisciplinary expertise. Success will depend on continued institutional evolution, methodological innovation, and commitment to collaborative approaches that can address the scale and urgency of contemporary global problems.

The evidence compellingly demonstrates that multidisciplinary research is not merely beneficial but essential for addressing the complex, interconnected challenges that define our global future. Realizing this potential requires sustained commitment to removing barriers, developing supportive structures, and fostering collaborative cultures that can generate the transformative solutions needed for addressing humanity's most pressing challenges.

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