

The Role of Teacher Preparedness and Institutional Capacity in Delivering Climate Change Education: A Review

Riaz Rizwan Ali^{*1}, Ubaadah Bin Iqbaal², Fazleen Farhat Bibi³, Roheb Rihaan Ali⁴

1 College of Humanities, Education and Law, Fiji National University, Fiji Islands.

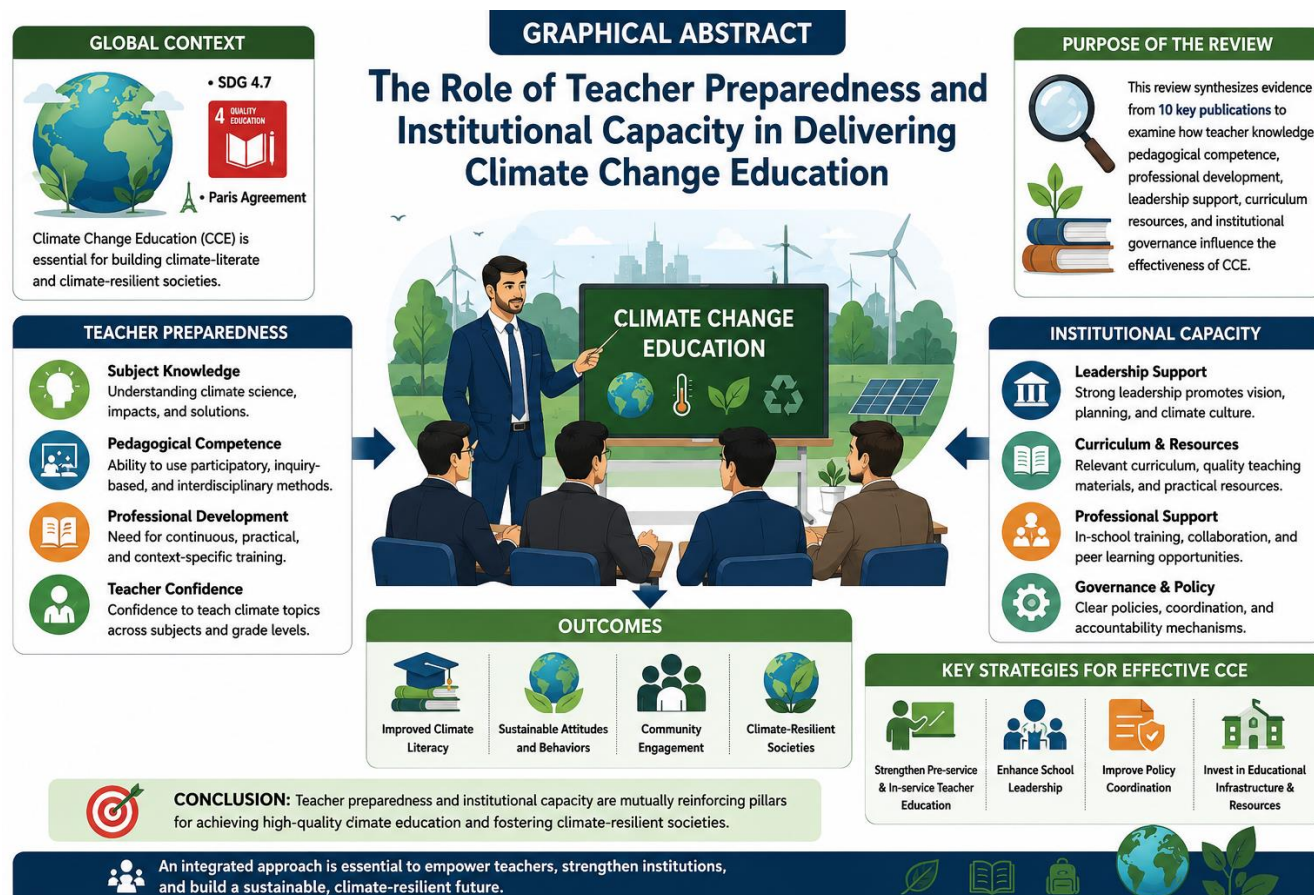
*Corresponding Author (riazrali10@gmail.com)

2 College of Engineering and Technical Vocational Education and Training, Fiji National University, Fiji Islands. (ubaadahi@gmail.com)

3 College of Humanities, Education and Law, Fiji National University, Fiji Islands (fazleenbibi786@gmail.com)

4 College of Humanities, Education and Law, Fiji National University, Fiji Islands (riaz.dingjin666@gmail.com)

DOI: <https://doi.org/10.70670/sra.v4i1.2487>



Abstract

Climate Change Education (CCE) has become a global priority under the United Nations Sustainable Development Goals (SDG 4.7) and the Paris Agreement. While many countries have integrated climate-related concepts into national curricula, successful implementation depends largely on teacher preparedness and institutional capacity. This review synthesizes evidence from ten key publications to examine how teacher knowledge, pedagogical competence, professional development, leadership support, curriculum resources, and institutional governance influence the effectiveness of CCE. The literature consistently indicates that teachers recognise the importance of climate education but frequently report inadequate training, limited teaching resources, and insufficient institutional support. Strengthening pre-service and in-service teacher education, enhancing school leadership, improving policy coordination, and investing in educational infrastructure are identified as essential strategies for delivering effective climate change education. The review concludes that teacher preparedness and institutional capacity are mutually reinforcing pillars for achieving high-quality climate education and fostering climate-resilient societies.

Keywords: Climate change education, teacher preparedness, institutional capacity, sustainability education, teacher professional development, SDG 4.7

Introduction

Climate change represents one of the greatest challenges facing contemporary societies. Education is widely recognised as a critical mechanism for promoting climate literacy, encouraging sustainable behaviours, and preparing future generations to address environmental challenges. International frameworks, including UNESCO's Education for Sustainable Development (ESD) initiative and the Paris Agreement, advocate integrating climate change across educational systems.

Despite widespread policy support, implementation remains uneven. UNESCO reports that although most national curricula include environmental or sustainability themes, relatively few teachers feel adequately prepared to teach climate change effectively. Furthermore, institutional limitations—including insufficient leadership, inadequate funding, limited teaching materials, and weak policy implementation—continue to hinder successful delivery of climate change education (CCE).

Teacher Preparedness for Climate Change Education

Teacher preparedness refers to educators' knowledge, pedagogical skills, confidence, and motivation to integrate climate-related concepts into classroom teaching. Across the literature, teacher preparedness consistently emerges as the strongest predictor of successful CCE implementation.

UNESCO and Education International's global survey involving more than 58,000 teachers found that although 95% considered climate change education important, fewer than 40% felt confident teaching the topic, while approximately one-quarter reported not being ready to teach climate-related themes. Limited subject knowledge and insufficient professional development were identified as major barriers.

Similarly, OECD (2022) emphasises that teachers require not only scientific knowledge but also pedagogical strategies that promote critical thinking, systems thinking, and climate action. Effective climate education extends beyond factual instruction to developing learners' competencies for sustainable decision-making.

Research further indicates that pre-service teacher education frequently provides limited opportunities to develop climate literacy. Beach (2023) argues that teacher education programmes should integrate interdisciplinary climate content, environmental justice perspectives, and systems thinking while enhancing teachers' self-efficacy for addressing controversial environmental topics.

Professional development also plays an essential role. Continuous in-service training enables teachers to update scientific knowledge, adopt innovative teaching methods, and respond to rapidly evolving climate

challenges. Evidence suggests even short, targeted training programmes significantly improve teachers' confidence in teaching climate-related concepts.

Table 1. Summary of key studies on teacher preparedness and climate change education

Author(s)	Year	Study Focus	Major Findings
UNESCO & Education International	2022	Global teacher survey on Education for Sustainable Development (ESD) and Global Citizenship Education	Teachers were highly motivated to teach climate change, but many reported insufficient knowledge, confidence, and training to deliver climate education effectively (UNESCO, 2022). (unesdoc.unesco.org)
OECD	2022	Teaching for Climate Action	Climate education should move beyond scientific literacy to developing student agency, problem-solving, and climate action competencies (OECD, 2022). (oecd.org)
Beach	2023	Teacher preparation for climate crisis	Teacher education programmes require interdisciplinary climate content, systems thinking, and environmental justice perspectives.
Anderson	2013	Climate change education	Effective climate education requires active learning, local relevance, and teacher competence in climate science.
UNESCO	2026	Greening Teacher Training	Strengthening pre-service and in-service teacher education is fundamental for climate-resilient education systems. (unesco.org)

Institutional Capacity and Educational Systems

Institutional capacity encompasses the organisational structures, leadership, governance, financial resources, curriculum frameworks, infrastructure, and policy coordination necessary for effective educational delivery. UNESCO identifies institutional strengthening as one of the four pillars of its Greening Education Partnership, highlighting that climate-ready education systems require coordinated planning, teacher standards, curriculum reform, financing, and school leadership.

OECD (2024) similarly argues that transforming education systems requires systemic reforms rather than isolated curriculum changes. Schools need supportive governance structures, cross-curricular integration, resilient infrastructure, and partnerships with communities to promote climate resilience effectively.

Institutional leadership strongly influences teachers' willingness to implement innovative environmental education practices. School leaders who prioritise sustainability can facilitate professional development, allocate instructional resources, encourage interdisciplinary collaboration, and establish whole-school approaches to climate action.

At national levels, ministries of education play a critical role through curriculum development, teacher standards, quality assurance, funding mechanisms, and monitoring systems. Weak institutional coordination frequently results in fragmented implementation despite ambitious curriculum policies.

Table 2. Major barriers affecting climate change education

Barrier	Description	Supporting Literature
Limited teacher knowledge	Teachers often lack sufficient climate science knowledge to confidently teach the subject	UNESCO (2022); Beach (2023) (unesdoc.unesco.org)
Inadequate professional development	Few structured training programmes are available for climate education	UNESCO (2022); OECD (2022) (unesdoc.unesco.org)
Limited teaching resources	Schools frequently lack updated instructional materials and digital resources	UNESCO (2026) (unesco.org)
Weak institutional leadership	School leaders often have limited capacity to coordinate climate initiatives	OECD (2024) (oecd.org)
Curriculum implementation gaps	Climate topics exist in policy but are inconsistently implemented in classrooms	UNESCO (2022); Anderson (2013) (unesdoc.unesco.org)

Challenges Affecting Climate Change Education

Several recurring barriers emerge across the reviewed literature:

- Limited pre-service and in-service teacher training
- Insufficient climate-specific teaching materials
- Low teacher confidence regarding climate science
- Weak institutional leadership and governance
- Limited funding for professional development
- Inadequate monitoring and evaluation systems
- Fragmented curriculum integration
- Unequal institutional capacity across regions

UNESCO's global analyses indicate that many countries have successfully introduced climate concepts into curricula without simultaneously strengthening teacher education, resulting in implementation gaps between policy and classroom practice.

Additionally, climate-related disasters increasingly disrupt educational systems, further highlighting the need for resilient institutions capable of maintaining learning continuity during environmental emergencies.

Table 3. Components of institutional capacity for effective climate change education

Institutional Component	Role in Climate Change Education	Key References
Educational leadership	Promotes sustainability culture and supports teachers	OECD (2024) (oecd.org)
Curriculum policy	Integrates climate concepts across disciplines	UNESCO (2026) (unesco.org)
Teacher professional development	Improves pedagogical competence and climate literacy	UNESCO (2022); Beach (2023) (unesdoc.unesco.org)
Learning resources	Provides teaching materials, laboratory support, and digital tools	UNESCO (2026) (unesco.org)
Cross-sector collaboration	Links education with	OECD (2024); UNESCO (2026) (oecd.org)

	environmental and climate institutions	
--	--	--

Strategies for Strengthening Teacher Preparedness and Institutional Capacity

The reviewed literature consistently recommends several evidence-based strategies:

- Integrate climate change comprehensively into pre-service teacher education.
- Expand continuous professional development focused on climate literacy and innovative pedagogy.
- Develop nationally aligned teaching resources and digital learning materials.
- Strengthen educational leadership through climate-focused school management.
- Improve coordination between education, environment, and climate ministries.
- Establish professional teaching standards incorporating climate competencies.
- Increase investment in resilient educational infrastructure and institutional capacity.
- Promote interdisciplinary and community-based approaches to climate learning.

These strategies align with UNESCO's Greening Education Partnership, which promotes climate-ready education systems through coordinated policy, institutional reform, and teacher capacity development.

Table 4. Recommended strategies for strengthening climate change education

Strategy

Strategy	Expected Outcome	Supporting Literature
Integrate climate education into pre-service teacher education	Improved teacher preparedness before entering the profession	Beach (2023); UNESCO (2026) (unesco.org)
Continuous in-service training	Enhanced confidence and updated climate knowledge	UNESCO (2022) (unesdoc.unesco.org)
Strengthen institutional leadership	Better implementation of school-wide climate initiatives	OECD (2024) (oecd.org)
Develop standardised climate teaching resources	Improved classroom instruction and consistency	UNESCO (2026) (unesco.org)
Foster interdisciplinary and community partnerships	Greater student engagement and climate action	OECD (2022); Anderson (2013) (oecd.org)

Future Perspectives

Climate change education is expected to evolve from a predominantly environmental science topic into a comprehensive interdisciplinary framework that equips learners with the knowledge and competencies required to address complex global sustainability challenges. Future educational systems should therefore strengthen teacher preparedness by integrating climate literacy with emerging developments in artificial intelligence, environmental sustainability, biotechnology, food systems, public health, engineering, governance, and digital innovation. Such an approach would enable teachers to cultivate systems thinking and problem-solving skills that reflect the interconnected nature of climate change and sustainable development.

One of the foremost priorities is the transformation of teacher education programmes. Future pre-service and in-service professional development should move beyond traditional environmental education by incorporating interdisciplinary scientific knowledge alongside innovative pedagogical approaches. The growing application of artificial intelligence in education demonstrates how digital technologies can personalise learning, improve student engagement, and strengthen critical thinking, suggesting considerable opportunities for climate change education through AI-assisted instructional tools (Kamal et al., 2026; Faizi

et al., 2026). Likewise, advances in AI-supported decision-making, automation, cybersecurity, and entrepreneurship indicate that future educators should be equipped with digital competencies that enable them to prepare learners for technology-driven sustainable societies (Naeem et al., 2026a; Naeem et al., 2026b; Naeem et al., 2026c).

Climate change education should also strengthen connections with food security, nutrition, and sustainable agriculture, recognising that climate change directly affects global food systems. Research on sustainable protein development, plant-based foods, functional foods, food safety, and novel food processing technologies illustrates scientific innovations that can serve as authentic case studies for teaching sustainability, circular bioeconomy, and responsible resource management (Khan et al., 2024; Ahmed et al., 2024; Butt et al., 2024; Butt et al., 2025a; Butt et al., 2025b; Riaz et al., 2026a; Butt et al., 2026a; Butt et al., 2026b; Butt et al., 2026c; Butt et al., 2026d; Butt et al., 2026e). Rather than treating food science separately from climate education, future curricula should demonstrate how sustainable food production contributes to climate mitigation, environmental stewardship, and resilient food systems.

Future climate education should further emphasise the relationship between environmental change and human health. Climate-induced changes in nutrition, infectious diseases, physical activity, chronic inflammation, and environmental exposure increasingly influence population health outcomes. Contemporary research examining dietary interventions, metabolic health, micronutrients, gut microbiota, musculoskeletal health, and environmental toxicology provides valuable interdisciplinary contexts through which educators can explain climate-related health risks and resilience strategies (Rashid et al., 2026; Mahmood et al., 2026; Butt et al., 2026f; Butt et al., 2026g; Butt et al., 2026h; Nawaz et al., 2026). Similarly, investigations into heavy metal contamination, microplastics, aquatic toxicology, and environmental pollutants demonstrate the importance of integrating ecosystem health with public health education (Riaz et al., 2026b; Ullah et al., 2026a; Ullah et al., 2026b).

Another promising direction involves incorporating biotechnology and molecular sciences into climate literacy. Emerging advances in genome editing, nutrigenomics, epigenetics, and precision fermentation illustrate how scientific innovation may contribute to climate-resilient agriculture, sustainable food production, and environmental adaptation without implying that these studies specifically addressed climate education (Fatima et al., 2026; Jabeen et al., 2025; Butt et al., 2026i; Butt et al., 2026j). These developments provide authentic examples that teachers can use to explain scientific responses to global environmental challenges.

Institutional capacity should likewise evolve towards whole-system sustainability governance. Educational institutions can learn from broader research on organisational governance, sustainability performance, strategic risk management, workforce wellbeing, and institutional resilience when designing climate-responsive educational policies. Although these studies are not focused on education, they demonstrate organisational principles that can inform leadership development, institutional planning, and sustainable management practices within educational settings (Khurshid et al., 2026; Butt & Yiwen, 2026; Rehman et al., 2026).

Climate literacy should also encourage learners to appreciate the contribution of engineering and advanced technologies in addressing climate challenges. Research involving adaptive power systems, fusion energy, computational modelling, artificial intelligence, and advanced diagnostics highlights the importance of technological innovation in supporting sustainable development (Shah & Butt, 2026; Awais & Butt, 2026; Arif et al., 2026). These disciplines can broaden classroom discussions by illustrating how engineering solutions complement environmental conservation and climate adaptation efforts.

Finally, future climate education should promote inclusive, socially responsive, and globally connected learning. Climate change disproportionately affects vulnerable populations, making social equity, migration, healthcare accessibility, community resilience, and quality of life essential components of future curricula. Research addressing migration, health inequities, student nutrition, periodontal health, and preventive

healthcare demonstrates how climate-related discussions can be linked with broader societal wellbeing and sustainable development objectives (Swati Khan et al., 2026a; Swati Khan et al., 2026b; Riaz et al., 2026c; Riaz et al., 2026d).

Overall, the future of climate change education lies in developing teachers who are capable of integrating knowledge across scientific, technological, environmental, health, engineering, and social disciplines while being supported by resilient educational institutions. The diverse body of literature reviewed here illustrates the breadth of contemporary research that can enrich climate change education through interdisciplinary teaching rather than by suggesting that each study directly investigated climate education. Such an integrated educational approach would better prepare learners to understand the complexity of climate change and contribute meaningfully to sustainable development.

Conclusion

Teacher preparedness and institutional capacity represent two interconnected foundations for successful climate change education. While teachers remain highly motivated to address climate issues, inadequate training, limited pedagogical confidence, and insufficient institutional support continue to restrict effective implementation. Evidence consistently demonstrates that curriculum reform alone is insufficient without simultaneous investments in teacher education, professional development, school leadership, governance, and educational infrastructure. Future educational policies should therefore prioritise comprehensive capacity building across all levels of education systems to ensure that climate change education effectively equips learners with the knowledge, skills, and values required for sustainable development and climate resilience.

References

1. Anderson, A. (2013). *Climate change education for mitigation and adaptation*. *Journal of Education for Sustainable Development*, 7(2), 191–206.
2. Beach, R. (2023). Addressing the challenges of preparing teachers to teach about the climate crisis. *Teacher Educator*, 58(4), 507–522.
3. OECD. (2022). *Teaching for Climate Action*. OECD Publishing. <https://doi.org/10.1787/d3a72e77-en>
4. Nusche, D., Fuster Rabella, M., & Lauterbach, S. (2024). *Rethinking Education in the Context of Climate Change: Leverage Points for Transformative Change*. OECD Education Working Papers No. 307. OECD Publishing. <https://doi.org/10.1787/fl4c8a81-en>
5. UNESCO. (2016). *Global Education Monitoring Report 2016: Education for People and Planet*. Paris: UNESCO.
6. UNESCO. (2017). UNESCO analysis indicates there is a gap in teacher capacity to deliver an ESD-integrated curriculum.
7. UNESCO. (2022). *Teachers Have Their Say: Motivation, Skills and Opportunities to Teach Education for Sustainable Development and Global Citizenship*. Paris: UNESCO.
8. UNESCO. (2026). *Greening Teacher Training and Education System Capacities*. Paris: UNESCO.
9. UNESCO. (2026). *Greening Education Partnership*. Paris: UNESCO.
10. United Nations Framework Convention on Climate Change (UNFCCC). (2026). *Progress in Implementing Climate Change Education, Training and Public Awareness*. Bonn: UNFCCC.
11. Khan, Waqas Ahmad, Muhammad Inam-ur-Raheem, Hina Rasheed, Muhammad Abdullah Butt, Farhan Saeed, Muhammad Afzaal, Faiyaz Ahmed, Noor Akram, Aasma Asghar, and Gebremichael Gebremedhin Hailu. "Comparative effect of olive oil and flaxseed oil on drug induced hepatotoxicity in rats." *Food Science & Nutrition* 12, no. 11 (2024): 9673-9681.

12. Ahmed, Naveed, Muhammad Saeed, Aasma Asghar, Muhammad Abdullah Butt, Muhammad Afzaal, Farhan Saeed, Rizwan Wahab et al. "Utilization of *Lactobacillus rhamnosus* as probiotic adjunct culture for the development of tempeh." *International Journal of Food Properties* 27, no. 1 (2024): 1279-1289.
13. Butt, Muhammad Abdullah, Rizwan Shukat, Muhammad Afzaal, Farhan Saeed, Ali Imran, Aftab Ahmed, Fakhar Islam et al. "Comparative evaluation of the quality and safety attributes of local and branded beef seekh kabab." *Cogent Food & Agriculture* 10, no. 1 (2024): 2360769.
14. BUTT, MUHAMMAD ABDULLAH, MUHAMMAD UMAIR ARSHAD, ALI IMRAN, and MUHAMMAD AFZAAL. "NUTRITIONAL AND BIOSAFETY ASSESSMENT OF A NOVEL SOY-WHEY HYBRID PROTEIN CROSSLINKED BY MICROBIAL TRANSGLUTAMINASE IN SPRAGUE DAWLEY RATS." *TPM–Testing, Psychometrics, Methodology in Applied Psychology* 32, no. S7 (2025): Posted 10 October (2025): 597-608.
15. Butt, Muhammad Abdullah, Muhammad Hameez Shahzad, Samiyah Tasleem, Rabiya Riaz, Xianjiang Ye, Burhan Khalid, Muhammad Atiq Ashraf et al. "Design of a Sustainable Whey–Corn Hybrid Protein Powder for Enhanced Nutrition, Functionality, and Environmental Stewardship." *Innovative Research in Applied, Biological and Chemical Sciences* 3, no. 2 (2025): 32-51.
16. BUTT, MUHAMMAD ABDULLAH, MUHAMMAD UMAIR ARSHAD, SAMIYAH TASLEEM, ALI IMRAN, and MUHAMMAD AFZAAL. "COMPARATIVE ANALYSIS OF CHICKEN AND MEAT ANALOGUE PATTIES: EVALUATING PHYSICOCHEMICAL, COOKING, TEXTURAL, MICROBIAL, AND SENSORY ATTRIBUTES." *TPM–Testing, Psychometrics, Methodology in Applied Psychology* 32, no. S6 (2025): Posted 15 September (2025): 1274-1285.
17. Rashid, Mian Shahan, Zubaria Gull, Muhammad Abdullah Butt, Sawera Hayat, Shnshah E. Azam, Shazia Saeed, Muhammad Mudassar Bashir et al. "The Role of Functional Probiotic Yogurt Consumption in Medical Weight Loss: A GLP-1 Friendly Nutritional Approach to Metabolic Health in UK Adults: <https://doi.org/10.5281/zenodo.19121209>." *Pakistan Journal of Medical & Cardiological Review* 5, no. 1 (2026): 1623-1632.
18. Kamal, Numra, Muhammad Abdullah Butt, and Umer Javeid. "An empirical study on the effectiveness of artificial intelligence tools in English language acquisition and teaching strategies within an ESG framework." *Social Science Review Archives* 4, no. 1 (2026): 3562-3568.
19. Mahmood, Basit, Minahil Arif, Hafiz Muhammad Moiz Basit, Beenesh Nadeem, Ammarah Abdullah, and Muhammad Abdullah Butt. "Long-term knee joint loading alterations in athletes 5 years post-ACL reconstruction: A comparative gait analysis." *Pakistan Journal of Medical & Cardiological Review* 5, no. 2 (2026): 310-321.
20. Butt, Muhammad Abdullah, Muhammad Asif Ali, Anam Ishaq, Ambreen Saleem, Sawera Hayat, and Nida Khalil. "The Influence Of Dietary Zinc Supplementation On The Expression Of Insulin-Like Growth Factor 1 (Igf-1) In Adolescent Athletes: <https://doi.org/10.5281/zenodo.19438363>." *Pakistan Journal of Medical & Cardiological Review* 5, no. 2 (2026): 12-19.
21. Butt, Muhammad Abdullah, Muhammad Asif Ali, Anam Ishaq, Ambreen Saleem, Shazia Saeed, and Mujahid Ul Islam. "Phytochemical-Rich Functional Diet Regulates Epigenetic Markers (DNA Methylation) Associated with Obesity and Insulin Resistance: <https://doi.org/10.5281/zenodo.19438403>." *Pakistan Journal of Medical & Cardiological Review* 5, no. 1 (2026): 2707-2715.
22. Fatima, Ambreen, Nadia Jabeen, Muhammad Abdullah Butt, Muhammad Noman, Talha Riaz, Shazia Saeed, Ambreen Saleem, and Qaisar Sohail. "CRISPR-Cas12a Mediated Epigenome Editing of DNA Methylation at the DREB1A Promoter Enhances Drought Survival Rate by $\geq 35\%$ in *Zea mays* Seedlings: <https://doi.org/10.5281/zenodo.20031798>." *Research Consortium Archive* 4, no. 2 (2026): 1093-1102.

23. Jabeen, Nadia, Musaffa Shahzadi, Muhammad Taha, Nida Shahzadi, and Muhammad Abdullah Butt. "CRISPR-Cas mediated genome editing for disease resistance in crops: advances and challenges." *Pakistan Journal of Medical & Cardiological Review* 4, no. 3 (2025): 2677-2689.
24. Riaz, Talha, Syed Tahaa Munawar, Ahmad Din, Muhammad Abdullah Butt, Sawera Hayat, Areej Azhar, Rabiya Riaz et al. "Microbiological safety, adulteration, and heavy metal-associated health risks in raw cow and buffalo milk from Punjab, Pakistan." *Food Science & Applied Microbiology Reports* 5, no. 1 (2026): 18-28.
25. Riaz, Talha, Areej Azhar, Zhijun Xia, Aliza Batool, Xianjiang Ye, Burhan Khalid, Muhammad Moeid Khan et al. "Advances in plant-based functional foods: Emerging trends, nutritional potential, and health implications." *Food Science & Applied Microbiology Reports* 5, no. 1 (2026): 1-17.
26. Naeem, Waleed, Muhammad Abdullah Butt, and Umer Javeid. "From entrepreneurship theory to startup execution: A simulation-based benchmark analysis of AI-enhanced venture decision systems in early-stage business performance." *Social Science Review Archives* 4, no. 1 (2026): 4065-4075.
27. Khan Swati, Menahil, Musaffa Shahzadi, Muhammad Taha, Nida Shahzadi, and Muhammad Abdullah Butt. "The impact of orthodontic treatment on periodontal health: gingival recession, bone loss and patient-specific risk factors." *Research Consortium Archive* 4, no. 2 (2026): 1198-1213.
28. Khan Swati, Menahil, Musaffa Shahzadi, Muhammad Taha, Nida Shahzadi, and Muhammad Abdullah Butt. "Silver diamine fluoride for caries arrest in pediatric and special needs populations: a decade of clinical evidence." *Pakistan Journal of Medical & Cardiological Review* 5, no. 2 (2026): 693-704.
29. Khurshid, Jamila, Zarlakhta Babar, Sajjad Ahmed, Muhammad Abdullah Butt, Umer Javeid, and Nida Khalil. "Beyond carbon footprints: unpacking the social dimensions of sustainability performance in emerging market firms." *Social Science Review Archives* 4, no. 1 (2026): 3386-3402.
30. Butt, Muhammad Abdullah, Anam Ishaq, Rizwan Shukat, Qaisar Sohail, Muhammad Hamid Javed, Ambreen Saleem, Shazia Saeed, and Muhammad Mudassar Bashir. "Clinical Effects of Post-Exercise Low-Carbohydrate Recovery Diets on Bone Mineral Turnover, Hormonal Stability, and Lean Mass Preservation in Endurance-Trained Adults." *Research Consortium Archive* 4, no. 2 (2026): 1586-1599.
31. Butt, Muhammad Abdullah, Feng Yiwen, and Umer Javeid. "Risk Governance Frameworks and Strategic Control Mechanisms for Managing Complexity in Global Business Operations." *Social Science Review Archives* 4, no. 2 (2026): 292-302.
32. Butt, Muhammad Abdullah, Muhammad Umair Arshad, Ali Imran, and Muhammad Afzaal. "Ultrasonication-Enhanced Microbial Transglutaminase Crosslinking of Botanical and Foreign Protein for Sustainable High-Moisture Extruded Meat Analogue: A Comprehensive Multidimensional Characterization." *Genetics and Molecular Research* (2026).
33. Shah, Muhammad Saleem, and Muhammad Abdullah Butt. "Multi-Scale Computational Investigation of Plasma Instabilities in Next-Generation Fusion Reactors." *Spectrum of Engineering Sciences* 4, no. 3 (2026): 2257-2266.
34. Arif, Neha, Hafsa Shafiq, Moiza Noor, Taha Shahbaz, Aswad Khan, Hafsa Noor, Khalil Ahmed, Eman Farrukh, and Muhammad Abdullah Butt. "Artificial Intelligence in Cardiovascular Diagnostics: Integration of Laboratory Biomarkers, Medical Imaging, and Molecular Data." *Pakistan Journal of Medical & Cardiological Review* 5, no. 2 (2026): 5665-5695.
35. Butt, Muhammad Abdullah, Wajid Hussain, Muhammad Junaid Anwar, Anam Ishaq, Luqman Khan, Muhammad Hammad Anwar, Talha Riaz et al. "AI-Guided Precision Fermentation for the Development of Personalized Functional Foods: A Food Technology Framework for Nutritional Optimization." *Research Consortium Archive* 4, no. 2 (2026): 2778-2795.

36. Awais, Muhammad, and Muhammad Abdullah Butt. "AI-DRIVEN ADAPTIVE PROTECTION SCHEMES FOR RESILIENT POWER SYSTEMS WITH HIGH PENETRATION OF DISTRIBUTED ENERGY RESOURCES." *Spectrum of Engineering Sciences* 4, no. 6 (2026): 1424-1434.
37. Butt, Muhammad Abdullah, Talha Riaz, Muhammad Abdullah Sadiq, Anam Ishaq, Ambreen Saleem, and Iza Almas. "AI-Assisted Nutrigenomic Modeling of Blueberry Anthocyanin–Gut Microbiome Interactions to Predict Butyrate Production and Insulin Sensitivity Improvement in Type II Diabetes." *Social Science Review Archives* 4, no. 2 (2026): 2159-2177.
38. Ullah, Saif, Muhammad Abdullah Butt, Qaisar Sohail, and Talha Riaz. "Multi-Omics Characterization of Fish Responses to Emerging Environmental Contaminants: Implications for Aquatic Toxicology and Sustainable Fisheries Management." *Pakistan Journal of Medical & Cardiological Review* 5, no. 2 (2026): 5666-5685.
39. Butt, Muhammad Abdullah, Talha Riaz, Muhammad Abdullah Sadiq, Anam Ishaq, Ambreen Saleem, and Iza Almas. "Development of Polyphenol-Rich Pomegranate Peel Nutraceuticals for Glycemic Regulation, Insulin Sensitivity Improvement, and Oxidative Stress Reduction in Type II Diabetes Mellitus." *Journal for Current Sign* 4, no. 2 (2026): 2398-2413.
40. Ullah, Saif, Muhammad Abdullah Butt, Qaisar Sohail, Talha Riaz, and Shazia Saeed. "Toxicological Evaluation of Microplastic and Nanoplastic Exposure on Growth Performance, Oxidative Stress Biomarkers, and Histopathological Alterations in Cultured Fish Species." *Social Science Review Archives* 4, no. 2 (2026): 2178-2198.
41. Naeem, Waleed, Muhammad Abdullah Butt, and Umer Javeid. "The Influence of Artificial Intelligence Automation on Employee Productivity, Job Redesign, and Organizational Performance in Service Industries." *Social Science Review Archives* 4, no. 2 (2026): 2534-2552.
42. Naeem, Waleed, Muhammad Abdullah Butt, and Umer Javeid. "Machine Learning-Based Fraud Detection Systems and Their Effectiveness in Reducing Cybersecurity Risks in Digital Banking." *Social Science Review Archives* 4, no. 2 (2026): 2553-2573.
43. Riaz, Muhammad, Neelam Tariq, Madiha Iqbal, Muhammad Abdullah Butt, Qaisar Sohail, and Talha Riaz. "Migration, Displacement, and Health Inequities: A Comparative Study of Refugee Populations and Access to Healthcare Services." *Social Science Review Archives* 4, no. 2 (2026): 2704-2722.
44. Riaz, Muhammad, Muhammad Abdullah Butt, Qaisar Sohail, Talha Riaz, and Ambreen Saleem. "Dietary Habits, Nutritional Status, and Socioeconomic Factors Among University Students in Punjab, Pakistan: A Multicity Nutritional and Social Survey." *Social Science Review Archives* 4, no. 2 (2026): 2723-2742.
45. Rehman, Anees Ur, Muhammad Abdullah Butt, Talha Riaz, and Qaisar Sohail. "Wellbeing-Oriented Human Resource Management and Workforce Sustainability in Healthcare Organisations: Comparative Evidence from Pakistan and Australia." *Journal for Current Sign* 4, no. 2 (2026): 3422-3440.
46. Faizi, Waqar Un Nisa, Saira Akhtar, and Muhammad Abdullah Butt. "The Impact of Artificial Intelligence-Assisted Learning on Academic Performance and Critical Thinking Skills Among Undergraduate Students." *Social Science Review Archives* 4, no. 2 (2026): 2925-2948.
47. Butt, Muhammad Abdullah, Anas Mustafa, Rizwan Shukat, Talha Riaz, Ambreen Saleem, Shazia Saeed, Muhammad Mudassir, and Qaisar Sohail. "Valorization of Watermelon Peel Flavonoids: Kaempferol, Quercetin, and Rutin as Natural Antioxidants for Functional Food and Nutraceutical Applications: <https://doi.org/10.5281/zenodo.21234696>." *Journal for Current Sign* 4, no. 2 (2026): 2761-2776.

48. Butt, Muhammad Abdullah, Anas Mustafa, Ahmad Din, Rizwan Shukat, Talha Riaz, Ambreen Saleem, Shazia Saeed, Muhammad Mudassir, Qaisar Sohail, and Muhammad Hamid Javaid. "Effects of Ultrasound-Assisted Protein Modification on the Functional and Nutritional Properties of Soy Protein Isolate." *Pakistan Journal of Medical & Cardiological Review* 5, no. 2 (2026): 5678-5704.
49. Nawaz, Hira, Nimra Shaukat, Ali Ahmad Bhatti, Moiza Noor, Savera Sayam, Tahira Yasmeen, Saira Fatima, Saira Sattar, and Muhammad Abdullah Butt. "Modulation of Gut Microbiota Through Functional Foods to Reduce Low-Grade Chronic Inflammation." *Pakistan Journal of Medical & Cardiological Review* 5, no. 1 (2026): 2231-2246.