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Sustainable diets, indigenous food systems, and planetary health: a regionally grounded review with Meghalaya, India as a case study

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Global food systems are major drivers of environmental degradation while failing to ensure optimal nutrition, particularly in low- and middle-income regions. Sustainable diets offer an integrative framework linking nutrition, environmental integrity, and socio-cultural sustainability. Indigenous food systems, especially in biodiversity-rich regions, represent context-specific pathways toward sustainable nutrition). Meghalaya, a predominantly tribal state in North-East India, provides a compelling case where rich agrobiodiversity and traditional food practices coexist with persistently high levels of undernutrition. This narrative review synthesizes interdisciplinary evidence on sustainable diets and planetary health and critically examines indigenous food systems using Meghalaya as a regionally grounded case study. Peer-reviewed literature and authoritative reports published between 2005 and 2024 were reviewed across nutrition, environmental science, ethnobotany, and food policy. National Family Health Survey-5 indicators are used solely to contextualize nutritional vulnerability, not as dietary intake data. Global evidence supports plant-forward dietary patterns for reducing environmental impacts and non-communicable disease risk. Indigenous food systems in Meghalaya align strongly with sustainable diet principles; however, structural constraints, nutrition transition, and gendered inequities limit their nutritional impact. NFHS-5 data highlight a paradox of ecological richness alongside high stunting and anemia, underscoring that biodiversity alone is insufficient to ensure nutrition security. We conclude that indigenous food systems hold significant potential to advance sustainable diets in Meghalaya, but translation into health gains requires integrated, context-specific strategies that address dietary quality, gender relations, health environments, and policy support.

KEYWORDS

agrobiodiversity, indigenous food systems, nutrition transition, planetary health, sustainable diets

1 Introduction

Food systems contribute nearly one-third of anthropogenic greenhouse gas emissions and are a major driver of biodiversity loss and freshwater use (Crippa et al., 2021; Poore and Nemecek, 2018). Simultaneously, malnutrition in all its forms continues to impose a substantial global health burden [Afshin et al., 2019; Food Agriculture Organization of the United Nations (FAO), 2023].

Sustainable diets have emerged as a unifying framework linking human health, environmental sustainability, cultural acceptability, and social equity

[Food and Agriculture Organization of the United Nations (FAO), 2010; High Level Panel of Experts on Food Security and Nutrition (HLPE), 2021]. Global syntheses, including the EAT–Lancet Commission, emphasize shifts toward plant-rich dietary patterns to achieve planetary health goals (Willett et al., 2019). However, these global dietary models have been critiqued for limited contextual sensitivity in regions facing persistent undernutrition and livelihood dependence on biodiversity (Drewnowski, 2020; Green et al., 2021).

Indigenous food systems embody many principles of sustainability, including diversified production, reliance on local biodiversity, and strong cultural embeddedness (Bharucha and Pretty, 2010; Kuhnlein et al., 2013). Meghalaya, where over 85% of the population belongs to indigenous communities, exemplifies this tension. NFHS-5 reports high levels of child stunting and anemia among women [International Institute for Population Sciences (IIPS) and ICF, 2021]. These data are used here only to contextualize vulnerability. Their limitations include cross-sectional design and inability to capture seasonal intake or indigenous food use.

2 Methods and conceptual framework

2.1 Rationale for a narrative review

A narrative review methodology was selected to enable integrative and critical synthesis across diverse disciplinary domains, including nutrition science, environmental studies, ethnobotany, anthropology, and food policy. Given the conceptual nature of sustainable diets and the contextual complexity of indigenous food systems, a narrative approach allows examination of theoretical debates, methodological diversity, and region-specific insights that are not amenable to meta-analysis. This approach supports critical comparison between global dietary frameworks and locally grounded food systems, which is central to the objectives of this paper.

2.2 Literature identification and selection

Literature was identified through structured searches of Scopus, Web of Science, PubMed, and Google Scholar, supplemented by targeted searches of FAO, HLPE, WHO, and EAT–Lancet repositories. Searches were conducted for publications between 2005 and 2024 using combinations of keywords including "sustainable diets," "planetary health," "indigenous food systems," "agrobiodiversity," "nutrition transition," and "North-East India."

Inclusion criteria comprised: (i) peer-reviewed research articles, reviews, and major policy reports; (ii) studies addressing diet–environment–health linkages; (iii) literature on indigenous or traditional food systems; and (iv) regional studies relevant to India and North-East India. Sources were selected based on relevance, scientific rigor, and contribution to conceptual or empirical understanding. NFHS-5 documents were included solely to contextualize nutrition indicators and population vulnerabilities.

2.3 Conceptual framework

The review integrates sustainable diets and planetary health frameworks with indigenous food systems scholarship. It critically examines how global plant-forward dietary models align with, diverge from, and sometimes oversimplify the realities of indigenous food environments, particularly where undernutrition, livelihood dependence on biodiversity, and socio-cultural dimensions are central.

3 Global sustainable diet frameworks and their limits

Global research consistently links plant-forward dietary patterns with lower risks of non-communicable diseases and reduced environmental footprints. Large cohort studies and pooled analyses from high-income regions demonstrate that diets rich in whole grains, fruits, vegetables, legumes, and nuts are associated with lower incidence of cardiovascular disease, type 2 diabetes, and all-cause mortality (Afshin et al., 2019; Springmann et al., 2018). From an environmental perspective, life-cycle assessments show that food production is a leading contributor to climate change, land degradation, and biodiversity loss, with animal-source foods—particularly ruminant meat—generally exerting higher greenhouse gas emissions and land use demands than most plant foods (Poore and Nemecek, 2018; Clark et al., 2020).

These findings underpin global policy frameworks promoting sustainable diets, including the FAO definition and the EAT–Lancet planetary health diet [Food and Agriculture Organization of the United Nations (FAO), 2010; Willett et al., 2019]. Such models advocate shifts toward plant-rich dietary patterns while allowing modest amounts of animal-source foods. However, these global dietary templates are primarily derived from modeling studies and epidemiological data from high-income contexts. They often assume stable food availability, diverse market access, and low prevalence of energy and micronutrient deficiencies.

In low- and middle-income regions, and particularly in indigenous settings, the dominant nutritional challenge is frequently inadequacy rather than excess. Seasonal food insecurity, limited dietary diversity, infections, and poverty shape nutrition outcomes. Critics of global plant-forward models caution that without adequate diversification and attention to bioavailability, predominantly plant-based diets may fail to meet requirements for iron, zinc, vitamin B12, calcium, and high-quality protein (Drewnowski, 2020; Beal et al., 2023). Thus, while global sustainable diet frameworks provide essential environmental benchmarks, they require contextual adaptation to avoid unintended nutritional trade-offs.

4 Indigenous food systems in India: alignments and tensions

India hosts more than 700 tribal communities whose food systems are shaped by diverse agro-ecological zones, cultural practices, and subsistence strategies. Indigenous diets commonly integrate cultivated crops with wild edible plants, minor millets,

tubers, mushrooms, insects, fish, and fermented foods (Arora and Pandey, 2020; Mahapatra and Panda, 2012). These systems are typically characterized by polycropping, seasonal harvesting, and low external input use, which support ecosystem services, dietary diversity, and climate resilience [Bharucha and Pretty, 2010; High Level Panel of Experts on Food Security and Nutrition (HLPE), 2021].

From a sustainable diets perspective, indigenous food systems align strongly with principles of agrobiodiversity, cultural appropriateness, and ecological stewardship. Nutritional studies indicate that wild greens, forest fruits, and traditional fermented products can contribute significantly to micronutrient intake and dietary quality (Johns and Eyzaguirre, 2006; Kuhnlein et al., 2013). Environmentally, such systems tend to have lower carbon footprints and support landscape-level biodiversity compared to industrial monocultures (Fanzo et al., 2022).

However, this alignment coexists with persistent nutritional vulnerability. National data show that tribal populations experience disproportionately high levels of stunting, anemia, and micronutrient deficiencies [International Institute for Population Sciences (IIPS) and ICF, 2021; Meshram et al., 2021]. These outcomes reflect structural constraints, including poverty, inadequate sanitation, limited health services, restricted land access, and social marginalization. Indigenous food systems therefore cannot be understood solely as ecological assets; they are embedded within socio-economic and political contexts that shape food access, utilization, and care practices.

5 Meghalaya as a regional case study: biodiversity, diets, and nutritional outcomes

Meghalaya is characterized by exceptional ecological heterogeneity, with forest-based landscapes supporting a wide range of cultivated and wild food species. Indigenous food systems among the Khasi, Garo, and Jaintia communities integrate shifting cultivation, home gardens, foraging, fishing, and small livestock rearing. Ethnobotanical surveys document the use of more than 200 edible plant species, including leafy greens, tubers, fruits, spices, and medicinal foods (Sawian et al., 2007). Traditional fermented products such as tungrymbai and nakham contribute to dietary diversity and may provide functional benefits (Das et al., 2021).

Despite this richness, NFHS-5 indicators reveal persistent public health concerns. Nearly half of children under five are stunted, and anemia affects a substantial proportion of children and women [International Institute for Population Sciences (IIPS) and ICF, 2021]. These data are used here to contextualize nutritional vulnerability. They do not capture dietary intake, seasonal food access, or the consumption of indigenous foods, and they are limited by cross-sectional design and recall-based reporting.

The Meghalaya case illustrates a critical biodiversity–nutrition disconnect. Ecological abundance exists at the landscape level, yet actual consumption is shaped by seasonality, time poverty, market dependence, erosion of traditional knowledge, and changing food preferences. For many households, access to diverse indigenous foods is intermittent, and younger generations increasingly favor market foods over traditional preparations. These dynamics constrain the translation of biodiversity into sustained nutritional gains.

6 Discussion

This review demonstrates that the presence of biodiverse food environments does not automatically translate into improved nutritional status. Biodiversity offers nutritional potential, but outcomes depend on accessibility, knowledge systems, health environments, and gender relations. The Meghalaya case aligns with broader evidence from low- and middle-income countries showing that malnutrition is shaped by interacting dietary and non-dietary determinants, including sanitation, infection burden, maternal health, and socio-economic inequality (Black et al., 2013).

Importantly, current evidence on indigenous diets remains methodologically limited. There is a paucity of region specific dietary intake data, systematic seasonality assessments, and standardized nutrient composition databases for indigenous foods. These gaps constrain the ability to quantify the true dietary contribution of agrobiodiversity and to rigorously evaluate the effectiveness of indigenous food-based interventions.

6.1 Limits of biodiversity and plant-based diets

While indigenous and plant-forward diets are often environmentally advantageous, they are not inherently nutritionally sufficient. Micronutrient gaps, limited bioavailability, and seasonal scarcities can undermine dietary adequacy. Iron and zinc from plant sources may be poorly absorbed, and vitamin B12 is largely absent from unfortified plant foods (Beal et al., 2023). Sustainable diet strategies in indigenous regions must therefore consider appropriate dietary diversification, culturally acceptable animal-source foods, fortification where feasible, and infection control to enhance nutrient utilization.

6.2 Nutrition transition and ultra-processed foods

The expansion of packaged and ultra-processed foods into rural markets has reshaped food environments across North-East India (Baker et al., 2020). These foods are energy-dense yet micronutrient-poor and are associated with rising risks of obesity, metabolic disorders, and hidden hunger (Monteiro et al., 2019). In Meghalaya, undernutrition increasingly coexists with emerging diet-related non-communicable diseases, reflecting an early stage of the double burden of malnutrition (Popkin et al., 2020).

6.3 Gender dimensions and care practices

Women are central to indigenous food systems as cultivators, foragers, processors, and caregivers. However, heavy workloads, limited decision-making power, and inadequate access to health and nutrition services constrain their own nutritional status and their capacity to translate food availability into child nutrition (Rao et al., 2018; Smith and Haddad, 2015). High anemia prevalence among women in Meghalaya underscores the need to integrate gender-responsive approaches into food system and nutrition interventions.

7 Implications for sustainable food systems and nutrition policy

The findings underscore the need for food system based strategies that move beyond calorie sufficiency toward dietary quality, sustainability, and cultural relevance. Indigenous food systems should be recognized as strategic assets within state and national nutrition frameworks rather than treated as informal or residual practices.

7.1 Integrating indigenous foods into nutrition programs

Public programs such as POSHAN Abhiyaan, ICDS, and the Mid-Day Meal Scheme offer platforms for incorporating locally available millets, pulses, tubers, and green leafy vegetables. Evidence from pilot initiatives suggests that locally sourced foods can improve micronutrient intake, support local livelihoods, and reduce environmental footprints (NITI Aayog, 2021; Fanzo et al., 2022). However, operational challenges include seasonality, procurement logistics, food safety regulation, and the standardization of indigenous foods within institutional systems.

7.2 Policy coherence and sustainable development goals

Strengthening indigenous food systems contributes to multiple Sustainable Development Goals, including Zero Hunger, Good Health and Wellbeing, Responsible Consumption and Production, and Climate Action. Achieving these synergies requires coordination across agriculture, nutrition, environment, education, and tribal welfare sectors [High Level Panel of Experts on Food Security and Nutrition (HLPE), 2021; Food Agriculture Organization of the United Nations (FAO), 2023].

8 Way forward and research agenda

Future research should prioritize region-specific dietary intake studies, nutrient profiling of indigenous foods, and longitudinal analyses of food system change. Participatory approaches are essential for documenting traditional knowledge, strengthening community ownership, and co-designing culturally appropriate interventions (Kuhnlein et al., 2013). Women-centered value addition, small-scale processing, and market linkages can enhance both nutrition and livelihoods while safeguarding ecological integrity.

Embedding indigenous food systems within formal education, extension services, and public procurement mechanisms can help ensure their continuity and relevance under conditions of climate change and economic transformation.

9 Conclusion

Sustainable diets provide a powerful framework for addressing intertwined nutritional and environmental challenges. Indigenous food systems in Meghalaya align strongly with these principles, yet biodiversity alone does not ensure nutrition security. Translating ecological richness into sustained health gains requires integrated strategies that address dietary quality, gender equity, health environments, and policy support. Meghalaya offers a critical regional lens through which global sustainable diet frameworks can be refined to better reflect the realities of biodiversity-rich yet nutritionally vulnerable settings.

Author contributions

NM: Methodology, Formal analysis, Validation, Project administration, Supervision, Data curation, Software, Writing – original draft, Visualization, Investigation, Funding acquisition, Resources, Writing – review & editing, Conceptualization. CD: Methodology, Formal analysis, Project administration, Visualization, Data curation, Writing – original draft, Conceptualization, Resources, Writing – review & editing, Investigation, Validation. PD: Writing – original draft, Formal analysis, Methodology, Data curation, Validation, Investigation, Software, Writing – review & editing, Conceptualization. YL: Writing – original draft, Investigation, Formal analysis, Data curation, Writing – review & editing, Methodology. US: Methodology, Writing – review & editing, Data curation, Investigation. KA: Writing – review & editing, Formal analysis, Data curation.

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