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# Conceptualising food environments as social activity spaces: Insights from lived experience research in Thailand and Laos

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ABSTRACT

The study of food environments helps the understanding of food and nutrition insecurity, but its static, quantitative and physical focus requires complementary research through people's "lived experiences." Through exploratory qualitative and participatory research, we aimed to capture communities' views of food environments, how they navigate these spaces, and what constitutes inequitable exclusion therein. We conducted participatory mapping and focus group discussions with 90 participants across 16 rural and peri-urban communities in northern Thailand and northern Lao PDR between November 2022 and February 2023. The inductive qualitative analysis resulted in four key themes: i) Diverse and dynamic foodscapes require careful study for dietary diversity assessments; ii) The food environment contains strong relational elements and varied experiences across gender and ethnic groups; iii) Food security had important local expressions of food sovereignty and food solidarity; and iv) Food-related behaviour was deeply embedded in a broader livelihood and human insecurity context. We link these themes to the concept of social and physical "activity spaces," advancing food environment research towards lived experiences, behavioural dynamics, and invisible forms of exclusion. This approach highlights the limitations of standardised dietary diversity measures; and it can enable research and interventions that are sensitive to local realities and the broader human security context.

## 1. Introduction

Food and nutrition insecurity remain a pressing global health challenge as more than 685 million people worldwide were estimated to suffer from undernourishment in 2024 and over 2.6 billion individuals globally could not afford a healthy diet (FAO et al., 2025). Food environments play a key role in understanding food and nutrition insecurity as they influence people's dietary choices and nutritional outcomes through the diversity of food outlets, products, their quality, convenience, and prices (Cheung et al., 2021; Karanja et al., 2022; O'Meara et al., 2025; Odoms-Young et al., 2023; Turner et al., 2018) – for instance in the form of popularly known "food deserts" in the United States (Beaulac et al., 2009; Cummins, 2002). That food environments hold critical importance for global health became particularly visible during the COVID-19 pandemic, which demonstrated an intricate interplay between restricted physical movements and people's coping strategies to overcome these restrictions (e.g. with the rise of delivery services; Bene et al., 2021; O'Meara et al., 2022; Wallingford et al., 2023; Wang et al., 2022).

Understanding how food environments influence consumer dietary choices is an important priority for global health and food policy research as it can contribute to contextual interventions that promote healthier dietary choices (Turner et al., 2018). However, the empirical literature is dominated by quantitative, static, and supply-sided assessments of people's "exposure" to the food environment and the related availability, affordability, and accessibility of food therein (Gupta et al., 2023; Muzenda et al., 2022; Osei-Kwasi et al., 2020; Turner et al., 2017; Westbury et al., 2021), while scholars and practitioners call to advance

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food environment research with qualitative and mixed-method studies on the lived experiences in these environments (Spires et al., 2023). Our study responds to these calls.

Our research question was, "*How do people view and navigate their food environments, and what constitutes inequitable exclusion therein?*" To explore this question, we employed a participatory qualitative research design that emphasised the lived experiences of community members in urban and rural Thailand and Lao PDR. We selected Thailand and Lao PDR as culturally relatively close yet politically distinct contexts with different levels of economic development – both of which retain food insecurity challenges. Lao PDR has with 56.2 % the highest population share unable to afford a healthy diet among the Southeast Asian countries recorded in FAO et al. (2025), while its upper-middle-income country neighbour Thailand still exhibits a comparatively high rate of 16.8 % compared to lower-middle-income Viet Nam with 8.8 %. Within the two countries, the regional economic hubs of Chiang Mai City and Vientiane City are comparable in size (between 800,000 and 900,000 inhabitants) and are located in the same topographic and climatic region. Both sites exhibit varied terrain and high ethnic diversity with more than a dozen ethnic minority groups each. While the Lao government has been relatively stable since the civil war ended in 1975, Thailand's constitutional monarchy has experienced repeated military coups over the same period and current relationships, especially between rural populations in Chiang Mai and the current military-backed government, are showing increasing tension and livelihood insecurity. This mix of geographical proximity and cultural similarities alongside different degrees of economic development and political fragility make Thailand/Chiang Mai and Lao PDR/Vientiane particularly interesting candidates for a comparative analysis.

The main argument of our analysis is that the lived experiences of food environments exhibit often neglected social and political complexities that stress the need for in-depth qualitative study in the food environments and that can usefully be captured through complementary frameworks such as activity spaces, which we will develop in detail in the discussion section.

## 2. Conceptual, methodological, and empirical literature on food environments

Food environments have been conceptualised as the "interface where people interact with the wider food system to acquire and consume food" (Turner et al., 2018:95) and comprise thus the totality of physical, economic, social, cultural and political factors that influence where, when, and how people engage with the food system (Grace, 2016; Turner et al., 2020). Aside from their spatial and market-based character, recent iterations in framing food environments place additional emphasis on individual food-related behaviour and the broader dynamic and non-market dimensions of the food environment (Gupta et al., 2023). To understand why households adopt certain food purchasing or acquisition practices and choose certain outlets/sources rather than others, an array of factors including affordability (Cummins, 2007b; MacNell et al., 2017), atmosphere and friendliness (Diez et al., 2017), physical attributes of outlets (Cannuscio et al., 2014; Chen and Kwan, 2015; Elliston et al., 2017) and transactional elements (e.g., credit) have been considered.

Broader social research has also considered the economic and sociocultural factors that mediate the influence of the food environment on diets, which help broaden the conceptual framing (Mattioni et al., 2020; Odoms-Young et al., 2023; Osei-Kwasi et al., 2020). One such bi-directional notion is that "food practices" embedded in specific social contexts may influence the utilisation of food environments, and food environments may influence these "food practices" by shaping "knowledge, norms and routines" related to food (Clary et al., 2017). Sociologists, anthropologists, and critical human geographers in particular have also expanded the conceptual understanding of food environments and practices, including their dynamic, relational, and socially constructed character. The idea of "foodscapes" for instance goes beyond a monolithic conceptualisation of food environments and considers the settings, spheres, and constellation of various actors that shape and are shaped by food-related practices including and beyond consumption (López Cifuentes and Sonnino, 2024; Mikkelsen, 2011). Among others, foodscape research has reshaped the traditional understanding of food environments by exploring digital interactions such as social media food trends or challenged the artificial distinction between food consumed at home vs. outside the home (Arciniegas, 2021). A further key concept in this domain is "foodways," which can be understood as cultural food practices that are situated within these foodscapes and their social, economic, political, and historical contexts (Chan, 2025). Institutional racism would for example not only describe but also be reproduced and resisted by everyday eating habits and responses to food environment interventions in US food deserts (Alkon et al., 2013). A broader but related framing that embraces these concepts is the "activity space," which derives from our research group's previous research on behavioural systems in the context of ecosystem conservation and the impacts of externally imposed policies and contextual change (Haenssgen et al., 2018, 2021, 2023; Mintz and Du Bois, 2002; Osei-Kwasi et al., 2020; Perchoux et al., 2013; Vaughan et al., 2017). Food activity spaces consider the food environment as a behavioural system at the interface of food systems and people. The physical and social activity space would comprise all food environment-related actors from individuals and households to formal/informal food providers (often in overlapping capacities as consumer-providers), the relationships among them, and the network of physical (e.g. roads) and social technologies (rules, norms, social capital, policies) that shape food-related behaviour (e.g. acquiring, storing, preparing, consuming, or otherwise disposing of foodstuff).

While we follow the standard definition of food environments, we conceptualise food environments in line with these broader notions – as not only physical but also as dynamic, relational, and socially constructed spaces that are encapsulated in notions of foodscapes, foodways, and activity spaces. Our conceptualisation thus foregrounds broader (consumer-centred) experiential dimensions (rather than external assessments), relationships (rather than physical arrangements), and situated practice (rather than exposure-related food choice considerations) within the food environment.

Methodologically, qualitative assessments that have informed especially the social research contributions in this field remain underrepresented. Food environment studies thus far have rather relied on relatively narrow physical and spatial assessments of food environments and on providing indicators of "exposure" to the food environment (Mackenbach et al., 2023). The principal empirical approaches comprise: (1) Geospatial mapping of food outlets using geographic information systems (GIS) techniques to map the density and proximity of different types of food outlets in a given "neighbourhood" or geographical area (Ambikapathi et al., 2021; Cetateanu and Jones, 2016; Christian, 2012; Gilcharan Singh et al., 2024; Muzenda et al., 2022; Turner et al., 2017; Wilkins et al., 2017); (2) Store audits that assess the range, prices/affordability, and quality of foods in specific outlets (Downs et al., 2022; Glanz et al., 2007; Gustafson et al., 2012; Partington et al., 2015); and (3) perception surveys that capture perceived availability, accessibility, affordability, and quality of foods or food outlets (Caldwell et al., 2009; Choudhury et al., 2025; Drewnowski et al., 2020; Inglis et al., 2008; Moore et al., 2008; Sharkey et al., 2010).

Perhaps surprisingly, systematic reviews of empirical food environment studies have generally found only weak or mixed links between physical and geographic measures of the food environment and dietary choices and nutritional outcomes (Caspi et al., 2012; Feng et al., 2010; Gustafson et al., 2013; Holsten, 2008; Zenk et al., 2011). Somewhat stronger links to dietary outcomes were found in studies that use perception-based measures of the food environment (Eskandari et al., 2022; Gupta et al., 2023; Turner et al., 2020; Westbury et al., 2021). Some of the weak linkages may be attributable to the variations in the

methods and techniques used in GIS studies related to data collection, accuracy, and classification of outlets (Boruff et al., 2012; Cummins, 2007a; Hillsdon et al., 2015; Li and Kim, 2020; Mackenbach et al., 2023). However, the principal weakness of physical and geospatial "exposure" measures in explaining dietary outcomes appears to arise from the fact that they do not capture lived experiences and social realities of places (see e.g. Lin, 2022) – that is, the local conceptualisation and actual use of the food environment by households and individuals on a daily basis (Muzenda et al., 2022; Spires et al., 2023). Exposure to food environments therefore may not translate into the use of food environments and exposure measures may not satisfactorily reflect the intention, ability or willingness to utilise food outlets and sources (Mattioni et al., 2020).

Recent reviews of empirical food environment research highlight that not only rural and peri-urban but also non-Western settings such as the Asian region and specifically Thailand and Lao PDR remain underrepresented (Cheung et al., 2021; Gilcharan Singh et al., 2024; O'Meara et al., 2025). These regional contributions focus on external food environments, specific population sub-groups, and/or particular types of foods such as fruits and vegetables while routinely highlighting (in both sites as well as the region) the challenges of expanding marketisation and monetisation of food environments alongside a persistent core of fresh markets as well as the continued role of informal, natural, and socially mediated food sources (Boonchoo et al., 2017; Chalermsri et al., 2020; Cheung et al., 2021; Choudhury et al., 2025; Farrell et al., 2021; Gilcharan Singh et al., 2024; O'Meara et al., 2025; Rousham et al., 2023; Zeitler et al., 2025). At the same time, empirical research (typically including Thailand but excluding Lao PDR) increasingly recognises non-physical access points in the external food environment such as online platforms as well as uneven power constellations within the broader food system (Cheung et al., 2021; O'Meara et al., 2024; O'Meara et al., 2025; Phulkerd et al., 2017).

Less attention in the empirical literature from the region has been devoted to qualitative explorations of how consumers experience and navigate their environments on a daily basis, social dynamics interweaving food practices, and systemic socio-political influences on individual and collective behaviours (whereby the review by O'Meara et al., 2025, offers insghtful examples) – that is, considerations around foodscapes, foodways, and activity spaces. The review by O'Meara et al. (2025) highlights this limited body of research, which documents for instance how women in the Asian region and elsewhere do not only experiences oppressive constraints on their agency in navigating food environments but are also frequently compelled to make trade-offs between their children's and their own food intake in situations of food insecurity. These rare examples also help go beyond the conventional yet simplified framing of behaviour as food choices conditioned by a closed-ended set of food environment factors, and explore instead lived experiences, intricate practices within and interactions with food environments, and socio-political considerations such as food sovereignty (Dwiartama et al., 2023; O'Meara et al., 2024; O'Meara et al., 2025).

Specific research from Thailand and Lao PDR highlights especially the role of the external market-based food environment in driving nutrition transitions while underscoring situation-, site-, and population-dependent food practices (Akiyama et al., 2024; Boonchoo et al., 2017; Dwiartama et al., 2023; Kounnavong et al., 2025; O'Meara et al., 2024; Rizaldo et al., 2024; Zeitler et al., 2025). For example, urban studies in Thailand tend to stress the consumption of increasingly available ultra-processed and convenient snack foods (Boonchoo et al., 2017; Rousham et al., 2023), while qualitative research in these settings has also highlighted interconnected poverty, power, and food behaviour struggles – and the role of agency therein (Dwiartama et al., 2023; O'Meara et al., 2024). Participatory research by Zeitler et al. (2025) focused on Indigenous Pgaz K'Nyau communities in northern Thailand and supported this perspective by documenting not only the diversity of relevant food environments (including the local ecosystem) but also varied foodways shaping behaviour in and perceptions of the food environment. Studies from Lao PDR are scarce but emerging work involving participatory research by Kounnavong et al. (2025) reflected these physical and social complexities. The study documented how young people in peri-urban settings accessed ultra-processed foods in schools while being influenced variously through their peers in the social environment of the school, whereas domestic settings rather fostered the consumption of fruits and vegetables (Kounnavong et al., 2025). Likewise, Rizaldo et al. (2024) highlighted that changes in the market-based external food environment foster this transition even in rural areas of Lao PDR that customarily depended on their local ecosystem as food source, but poorer segments therein continue to face food insecurity.

## 3. Material and methods

### 3.1. Research design

Similar to other lived experience research (Miewald et al., 2010; Neve et al., 2021; Turner et al., 2023), our study used a qualitative and participatory research design that aimed to capture communities' views of food environments, how they navigate these spaces, and what constitutes inequitable exclusion therein (Mayoux, 2006; Schensul et al., 2015). The participatory components included (a) working with study communities with whom our research team has had decades-long relationships; (b) involving community members in implementing the sampling strategy and facilitating and interpreting focus group discussions; and (c) participatory techniques within the qualitative data collection (e.g. community mapping).

While this study focuses on qualitative aspects, it is part of a broader mixed-method research project (other components reported elsewhere) whose aim it was to develop new methods to assess household exclusion from food environments, for which foundational qualitative research was essential. The team itself comprised international as well as local Thai and Lao researchers with a disciplinary range including nutrition and agricultural economics, medical and cultural anthropology, medical sciences, and development studies. The research was embedded in the study sites as the local teams in Thailand and Lao PDR had long prior research connections with the communities included in the present study. These connections ranged from at least three years to several decades and involved both ethnographic and transformative development research (for further background on these relationships, see e.g. Haenssgen et al., 2025; Leepreecha, 2019; Leepreecha and Duaidee, 2020; Leepreecha and Wanichpradit, 2009). The day-to-day data collection was supervised by Thailand- and Lao-PDR-based research staff and implemented by graduate-level Thai and Lao anthropologists (male and female) who also had experience in community development and participatory research techniques. These teams were supported by community-based team leaders who either lived in the study communities or otherwise were of the same ethnic group with existing connections to the communities (all-female in Lao PDR, mixed male and female in Thailand).

The exploratory scope of this research focuses on contextualised community-based experiences of food environments within rural and peri-urban settings of northern Thailand and northern Lao PDR during the winter season of 2022/2023. The limitations of this study focus pertain specifically to the generalisability of empirical findings (which qualitative research does not aspire to attain) outside of the specific case study and temporal setting as well as to urban and producer-focused perspectives.

### 3.2. Study sites

Thailand and Lao PDR afford interesting food environment research opportunities due to their culturally relatively similar yet politically distinct contexts with different levels of economic development. Thai per capita gross domestic product was approximately 2.2 times higher

than in Lao PDR (US$20,700 vs. US$9400 in purchasing power parity in 2017), whereby Lao PDR has not only recently been experiencing rapid rural transitions but also macroeconomic shocks including high inflation and an exchange rate slump (official consumer price inflation in 2022 stood at 23.0 % in Lao PDR and 6.1% in Thailand; Kibe et al., 2023; World Bank, 2023). The economic differences between the countries also reflected on food security indicators: more than one-third (35.6 %) of the Lao population were classified as moderately or severely food insecure in 2024, compared to 5.4 % in Thailand (FAO et al., 2025). Both countries have also experienced a rapid expansion of the formal market-based food environment – especially in the form of supermarkets and restaurants – albeit from a considerably lower base in Lao PDR (Rousham et al., 2023).

The specific study sites comprised four communities each in Chiang Mai Province and Vientiane Province (see Fig. 1 for a regional map). In Chiang Mai, two communities were located in the wider metropolitan area of Chiang Mai city (travel distance of approx. 30 min) and two communities comprised highland Indigenous communities (60–120 min travel distance) including Pgaz K'Nyau (a Karen sub-group) and Hmong groups who have been experiencing longstanding livelihood and human security challenges (Haenssgen et al., 2023). In Vientiane Province, the study sites reflected greater ethnic homogeneity of majority ethnic Lao Loum (lowland Lao) groups but varied levels of wealth and remoteness to their nearest urban area (travel distance from Vientiane approx. 60–90 min). Despite their seeming proximity, the social context of these settings was highly diverse and dynamic – for example with view towards gender. In the Chiang Mai highlands, Karen communities have traditionally been deemed more egalitarian than Hmong communities as Karen women "more than the men, are identified with the guardianship of traditional wisdom and the maintenance of traditional agricultural practices" (Nawarat, 2010:38) – whereas Hmong women are often excluded from participating in specific ritual activities such as the new year celebrations (Huang and Sumrongthong, 2004). However, gender norms have also evolved, especially with the rural transformation towards cash crop cultivation, off-farm income, and labour migration to the Thai lowlands in the 1980s and later – all of which have entailed a greater inclusion of women into formal economic activities (Hirai, 2002; Tungittiplakorn, 1998; Youdelis, 2013).


**Fig. 1.** Map of study sites in Thailand (Chiang Mai Province) and Lao PDR (Vientiane Province) Source: Adapted from Wikimedia Commons (2023), user maps from Infernoapple (*Provinces of Laos*) and NordNordWest (*Thailand location map*).

### 3.3. Data collection

Our data collection used focus group discussions supported by participatory mapping of the local food environment to stimulate the conversation (discussion guide provided in Supplemental Material 1). The 90-120-min conversations addressed dietary diversity, conceptions of food, the nature of food environments (including informal food exchanges), and how people make food choices. The conversations were open-ended to explore food-related subjects with as little prejudice as possible, including for instance guiding questions during the mapping activity such as "When we say 'food' in Thai (*ahan* or อาหาร), what do you think of? What about 'foodstuff' (*kongkin* or ของกิน)? Beside eating a meal as *kin khao* (กินข้าว in Thai; in Lao กิินเข้า), what else do people eat and drink during the day (e.g. snack, papaya salad, sour mango, milk tea, M-150, beer, smoothies)?" The discussion guide was developed directly in Thai and Lao through the anthropologically trained Thai and Lao community engagement specialists within our research team. The community-based team leaders co-facilitated the conversations and helped explore and explain local food items, specific locations and food practices, and local-language/-dialect terms that the native Thai and Lao speakers were not familiar with (e.g. older Pgaz K'Nyau participants would at times prefer to express themselves in their first language).

We selected small focus groups of approximately five participants to enable intensive discussion and to ensure that the participatory mapping process was manageable (Haenssgen, 2020).

Implemented between November 2022 and February 2023, we conducted 18 focus group discussions with 90 participants, each of whom was compensated with the local-currency equivalent of US$6 for their time. The groups were homogenous in terms of gender and ethnicity and aimed to elicit a wide range of viewpoints and experiences from key food decision makers from community households (as opposed to reaching a consensus view; Lloyd-Evans, 2006:157). The purposive sampling rationale stemmed from the broader research project within which this study was embedded, whose working hypotheses included that gender was a probable factor in shaping exclusion from food environments (as previous statistical research by our research team using accelerometers in other geographies had suggested; see Picchioni et al., 2020). A further reasoning for gender-specific focus groups was that mixed-gender groups may be dominated by senior male elders, as would often be the case in community consultations that our research teams carried out in the study regions over the past years. We thus selected one group each for male/female participants in each study site, plus an additional male/female discussion specifically with Hmong participants in an urban Thai community to capture local ethnic diversity (average 5.1 participants in female groups and 4.9 participants in male groups; see Table 1).

The Thai and Lao anthropologists worked closely with the community-based team members to recruit volunteers from the

**Table 1**
Overview of focus group discussion sessions.

| Site | Community | | | Participants | | |
|---|---|---|---|---|---|---|
| | Number | Location | Relative wealth | Ethnicity | Gender | Number of participants |
| **Thailand** | **1** | Urban | High | Khon Mueang (Thai) | Female | 5 |
| | | | | | Male | 4 |
| | **2** | Urban | High | Khon Mueang (Thai) | Female | 5 |
| | | | | | Male | 5 |
| | | | | Hmong | Female | 5 |
| | | | | | Male | 6 |
| | **3** | Rural | Medium | Hmong | Female | 4 |
| | | | | | Male | 5 |
| | **4** | Rural | Medium | Pgaz K'Nyau (Karen) | Female | 5 |
| | | | | | Male | 3 |
| **Lao PDR** | **1** | Peri-urban | Low | Lao Loum | Female | 5 |
| | | | | | Male | 6 |
| | **2** | Peri-urban | Medium | Lao Loum | Female | 5 |
| | | | | | Male | 5 |
| | **3** | Peri-urban | Medium | Lao Loum | Female | 5 |
| | | | | | Male | 5 |
| | **4** | Peri-urban | Low | Lao Loum | Female | 7 |
| | | | | | Male | 5 |

communities (with the additional aid of village chiefs as is customary and essential for research in rural Thailand and Lao PDR). The connections of the team to the local community helped overcome otherwise notable hesitancy to engage with community outsiders. However, communities are not universally harmonious and cohesive but can also contain divisions, factions, and conflict – and at times systematically so along class lines and the distribution of power in a community (Scott, 1985). Practically, this meant that we were to some extent also subject to the embeddedness of the community-based team members in recruiting participants and the requirement for them to manage their own personal relationships with the broader community.

The qualitative data were collected and audio-recorded in local languages (Lao, northern Thai, Hmong, Karen), transcribed verbatim, and translated into English by the Thai and Lao research team members (maps were photographed but are not presented in this manuscript to preserve the anonymity of the study communities). Prior informed and voluntary consent – for data collection as well as audio recordings – was elicited and recorded from all participants. The research was reviewed and approved by the University of Reading School of Agriculture, Policy and Development Ethics Committee (ref. 1961D) and the Lao PDR University of Health Sciences Research Ethics Committee (ref. 395/REC); the Chiang Mai University Research Ethic Committee waived separate review requirements following approval from the University of Reading. The qualitative data comprised 28:34 h of recorded discussion material equivalent to 414,000 words of interview transcripts (on average 1:35 h and 23,000 words of transcripts per discussion).

### 3.4. Data analysis

We analysed the data through an inductive thematic analysis approach (Haenssgen, 2020). The analysis process was mindful of the dynamic nature of the discussion process; we therefore considered statements in a broader conversation context rather than as isolated content. Using MAXQDA 2020 (VERBI Software, 2021), the first phase of the analysis involved four iterations of inductive coding (i.e. deriving themes from the textual material). These iterations proceeded with the familiarisation with the digitised material and open coding on one discussion transcript from each community to establish an initial codebook (codes applied to passages rather than individual statements to consider the conversational and interactive nature of the discussions). In the second iteration, we applied the initial codebook to the full body of the qualitative material, and, in the third iteration, revised and harmonised the coding scheme across all transcripts through constant comparison and clustered related codes into four overarching themes plus sub-themes (coding system together with number of coded instances provided in Supplemental Material 2). In the fourth iteration, we noted the specific expressions, interpretations, and representing quotes of the coding system. In the second phase, we engaged in the comparative analysis of the themes and sub-themes across different focus group discussion types, for example to understand the varied expressions of navigating food environments between men and women.

The analysis process was conducted jointly by the Thai- and Lao-based research teams (including the team members conducting the focus group discussions) to foreground local knowledge. To retain sensitivity to the community context given our position as outsiders, we also related back to the community-based team leaders who facilitated the focus group discussion. Given their residence in the local communities, their contextual knowledge helped interpret the topics arising from the analysis. These interactions took place in person and remotely (via video calls) both during the iterative coding to confirm and revise our identification of specific sub-themes and codes (e.g. confirming local ingredients, presence and accessibility of food outlets) and after the completion of the coding process to validate the interpretation of the main themes (partly in preparation for subsequent survey phases of the research project that are reported elsewhere).

## 4. Results

Our inductive qualitative data analysis resulted in four major themes relating to the complex socio-political nature of food environments: i) The diversity of foodscapes; ii) The dynamic and social character of food environments; iii) Food solidarity; and iv) The broader human security context in which these patterns materialise.

### 4.1. Diverse foodscapes

A key theme that we found across the focus group discussions was the diversity of local foodscapes, which pertained especially to the wide spectrum of food items in local circulation. Participants in both study sites naturally mentioned common local food items (e.g. rice, vegetables like eggplants, or fruits like mangoes) as well as dishes (e.g. fried rice dishes or sour papaya salad) that locally adapted dietary diversity measures can capture with ease. However, the wide range of food items also included less conventionally recognised elements including, for example,

- Insects such as "*grasshoppers, giant water bugs*" (Lao Site 4, female) or ant eggs, cockchafers, crickets, bamboo caterpillars, scarab beetles,

and "*E Niw* […]*, the insect that will grow into dragonflies*" (Thai Site 2, Khon Mueang, female).

- Varied local fruits and vegetables including tamarind and *mien* leaves (to wrap meat) and local food groups such as "*bitter curry vegetables*" (Lao Site 2, male) or "*sour fruits*" (Lao Site 1, female).
- Local types of flesh meat such as moles, mice, lizards, squirrels, crabs, shrimp, snails, frogs, and tadpoles.
- Spices and herbs such as black pepper and medicinal plants that are sometimes only customary to specific ethnic groups, as for instance the herb "*'Hor Wor'* [ห่อวอ] *is something unique of Karen*" (Thai Site 4, female).
- Dietary supplements, comprising for example collagen, herbal supplements (available in Thai convenience stores and pharmacies), and vitamins that are at times administered intra-venously at local clinics (Thai Site 2, Khon Mueang, female).
- Beverages including cereal drinks to replace meals as "*you don't eat a dish but you drink that*" (Thai Site 3, female; Thai respondents would relate this behaviour to drinking "*nam pa na*" [น้ำปานะ] meals as a Buddhist practice to refrain from chewing in the evening). However, the most discussed beverage type was alcoholic drinks (e.g., "*we buy alcohol and beer from the grocery store, then we drink it at home*," Lao Site 1, female; "*I used to drink a lot of alcohol*," Thai Site 1, male).
- Locally specific recipes such as "*laab* [minced pork salad] *with raw pork and blood*" (Lao Site 1, female) – often consumed with alcohol – and occasionally also raw beef, cabbage salads using the sour Lao fruit "*mak huad*" (Lao Site 4, female), a "*spicy worm and chili paste*" for dipping (Thai Site 4, female), or Coca-Cola-boiled chicken (Thai Site 4, male).
- Dried and fermented food, as villagers would make "*fermented fish, around 3–4 jars per year*" (Lao Site 3, male) or pickled or sun-dried cabbage (Thai Site 4, female).

Another important aspect was the variability in time, which shaped the availability and consumption of different food groups together with the physical and social context. Seasonal variation would shape local food supply in the rural and peri-urban study sites (e.g. availability of fruits, fish, or flesh meat obtained from rice fields), while all sites were equally subjected to social occasions like funerals and birthday parties and cultural events such as new year festivals (often opportunities to eat meat) or Buddhist lent (as an opportunity to fast and refrain from consuming alcoholic drinks). Similarly, respondents from all sites remarked on a gradual and generational eating transition afforded by exposure to Western dishes like pizza and the increasing availability of ready-to-eat snacks in the local market-based food environment.

Local foods and consumption patterns, the components of local dishes, and food preparation practices were thus highly diverse and at times unhealthy. While this dynamism helps situate other aspects and practices of the food environment, it also has potentially significant implications for understanding dietary and health outcomes of being included in local food environments. For example, as we will explore further in the third theme (Section 4.3), precarious livelihoods and stress-inducing activities would often be linked to participants highlighting a resort to ready-cooked bagged food for take-away.

### 4.2. Dynamic social spaces

The second major theme was the nature of the food environment as a dynamic social space. Aside from expected physical space elements such as super-/markets, grocery stores, temples, farm plots, other village households, or natural sources (plus delivery services), the experiences of navigating the food environment as a social space varied across gender and ethnic groups (alongside several other factors including access to transport, personal preferences, wealth, age, location). During the participatory mapping activities, male respondents routinely mentioned a noticeably wider range of market-based food outlets especially outside their communities, whereas female participants would more commonly highlight food sharing and exchange with neighbouring households. This differentiated navigation of the food environment was linked to gendered productive activities, in which men tended to engage more commonly with the formal cash economy whereas women were more likely to engage in non-monetised productive activities in the home or in the local environment. Both Thai and Lao male discussion groups thus highlighted how natural it was for them to eat out after work ("*We are tired after gardening, so we look for a restaurant to eat*," Lao Site 1, male). Female respondents "*can't go eat outside regularly*" (Lao Site 1, female) and would rather eat with their families at home or with friends during farmwork and foraging. Patterns of economic organisation thus shaped the social food spaces of men and women.

This was not a static situation. Rural development continually reshaped the spatiality of gendered production (as mentioned in Section 3.2) and the subsequent navigation of the food environment. Ethnicity accentuated this pattern. Participants of a Hmong female discussion group who migrated to an urban study site in Thailand often went out to buy ingredients for cooking – up to three times a day on grounds of freshness – but typically only from three shops within a 5-min radius from their homes. They would not regularly venture further either for shopping or foraging, arguing that, "*We have been here for a long time, but we are not familiar with many places. We know only places within our village. We don't know many other places except the market*" (Thai Site 2, Hmong, female). In the same location, majority Khon Mueang women listed a wider range of shops, markets, and supermarkets for their regular shopping behaviour, and both Khon Mueang and Hmong men described uninhibited patterns of accessing local bars, a-la-carte restaurants, and shops as part of their daily routines.

Navigating social spaces also meant that individuals could help extend others' access to the food environment. In the urban Thai sites, respondents would for instance highlight the role of their children as proxy actors in obtaining their food (e.g., "*If I want to eat* [something from delivery apps]*, I'd ask my children to order*," Thai Site 2, Hmong, female). The range of delivery options primarily revolved around interpersonal arrangements (phone calls and face-to-face arrangements) in the rural and peri-urban areas of our study, compared to modern apps and online shopping in the urban sites in Thailand (which, as the quote illustrated, may still require a proxy actor to utilise). Food delivery through apps and family members would not only be a convenience but enable especially older, mobility-impaired family members access to food. Delivery apps and services thereby shaped the food environment beyond its physical configuration, and they meshed into the food environment in tandem with the evolving economic and social landscape of the study sites (see next theme for further elaboration).

Female Lao participants further emphasised food sharing patterns as they cooked food together with other villagers at their farms and houses, all of whom would bring available ingredients ("R: *suppose I have bamboo, you have mushroom, another has rice, and another has papaya. We contribute*," Lao Site 1, female). On the other hand, social realities could also undermine food access through theft of farm produce (commonly mentioned in the Lao sites) or through competition for natural resources and food sources in peri-urban and rural settings: "*There is less fish now* […] b*ecause there are so many fishermen now, and the fish is not big yet* [when they catch it]" (Lao Site 2, female). Even the urban Thai sites experienced competitive restrictions in their food environment as it has become impossible to raise animals: "*We can't* [raise pigs here]. *Others will hate us*" (Thai Site 2, Khon Mueang, female). Likewise, accessing food through delivery services may provide further opportunities to engage with the food environment for some people, but it was not egalitarian. Urban Thai men commented indirectly on the cost constraints of food delivery if they needed to subsist on a small budget: "*If you order, at least it'd be 50 baht. For us, we can live with 30-40 baht*" (Thai Site 2, Khon Mueang, male). The social dimensions of the food environment thus shaped food-related behaviour across gender and ethnic groups in a dynamically changing economic and technological context

and with strong inter-personal elements such as food sharing and competition.

### 4.3. Food solidarity

The third major theme was food solidarity together with the related notion of sovereignty and as valued yet increasingly threatened alternatives to "inclusion" into the market-based food environment.

At face value, food insecurity appeared scarce in the study sites. Participants in both Thailand and Lao PRD were usually adamant that nobody in their neighbourhoods had been affected by severe malnutrition or starvation. However, their expressions would hint at moderate instances of food insecurity in all study sites. These expressions were particularly pronounced in the economically more vulnerable setting of Lao PDR, where respondents would repeatedly report that "*There are a lot* [of struggling families]. *They don't have enough food to eat*," Lao Site 3, female). Key drivers in the Lao setting were soaring inflation ("*Everything is expensive now*," Lao Site 1, male), seasonal access to naturally sourced food ("R: *During the rainy season, we can find a lot of forest things.* – R: *But it's difficult during the dry season*," Lao Site 4, male), and the recent COVID-19 restrictions ("*We lacked flour, meat, but fish we could find and also vegetables. But we lacked starch, lean meats, and also some seasoning like chili powder or MSG*," Lao Site 4, female). However, subtle expressions of food insecurity existed even in seeming medium-to high-income settings as Thai respondents would describe how "*some people might have three 4-wheel vehicles but still eat rice with water because they spent all their money on the vehicles*" (Thai Site 3, female).

These experiences of food insecurity (evidenced e.g. by skipping meals) took place in a discourse of neoliberal market integration. This sentiment was visible in such statements as, "*We don't have free food. We need to buy, even one chili we have to buy*" (Lao Site 3, female), which indicated market-based interactions to survive, and the need to work to access food as "*If you're not lazy, you won't starve*" (Thai Site 2, Khon Mueang, male; note how this common notion across all sites resembles the idea of the "undeserving poor" and the Protestant work ethic) (Halper, 1973). Market-based solutions to mitigate food insecurity would thus aim at retaining or reinstating people's participation in the market-based food environment: managing household finances more economically, generating income through casual labour or selling natural and home-grown food items ("*Sometimes we want to eat meat, we collect our products and sell it to buy meat to eat*," Lao Site 1, male), purchases on credit in neighbourhood shops, and, especially in Thailand, government aid and pensions to support poor and older people to enable access to shops and markets.

The participants described these options generally as viable as they "*don't think anyone starves anymore nowadays*" (Thai Site 4, male), but also problematised wastage and unhealthy eating patterns based on "*abundance and options*" in the market economy (Thai Site 3, female) and described casual labour and the proliferation of household and agricultural debt as sources of a risky and tenaciously self-dependent existence ("*debts are plentiful, nothing but debts;*" Thai Site 4, female). Where the market economy failed to provide options altogether, people would also have to rely on food theft and the risk of violence, which was a situation mentioned repeatedly in the Lao site ("*I am afraid that they* [who steal from my farmland] *will hurt me*," Lao Site 3, male).

As an alternative, rural and peri-urban communities in Thailand and Lao PDR highlighted elements of food sovereignty to attain food security (the declaration of Nyéléni, 2007:9, defines food sovereignty as, "the right of peoples to healthy and culturally appropriate food produced through ecologically sound and sustainable methods, and their right to define their own food and agriculture systems"). Several participants stressed that they had sufficient access to vegetables, fruits, fish, and meat from natural sources and their gardens – to the extent that their ability to maintain sovereignty of their food system could insulate their communities from market-based vagaries and pressures ("*Let's say the communities downhill face a crisis* [and can't supply us]*, then we can still survive.* […] *At least we can survive for a month or so,*" Thai Site 3, male). However, the ability to uphold principles of food sovereignty had also been undermined by the expansion of the cash economy together with broader socio-economic development. A key issue was the depletion of natural resources to sell foodstuff (e.g. tadpoles or fish) on the market. Government-managed conservation zones to preserve the remaining resources restricted villagers' ability to maintain self-sufficiency as well: "*Now the wild animals are protected by some organizations. It is delicious* [Laughed] *but we have to stop eating it. So I have to eat beef* [which can only be bought at the market] *to get the energy*" (Lao Site 3, male).

Food solidarity was another approach to communally overcome food insecurity challenges. Some communities (esp. one rural Thai study site) stressed their identity as a community where, "*Whoever comes, or if we encounter someone and they ask what they want to eat, we share*" (Thai Site 4, female). Some villagers described these exchange relationships as symbiotic ("*If they* [who exchange with me] *can survive, then I can survive*," Thai Site 4, male), but even less enthusiastic villagers emphasised solidarity in times of emergency and among smaller groups such as their neighbours. Lao participants also emphasised pooling their resources to cook and eat together ("R: […] *if she asks me to join her for eating papaya salad, I will go to eat with her.* […] R: *I don't buy it* [food]*, if it is not necessary,*" Lao Site 2, female). In addition, all communities had temples with food donations on which people could rely at least partially, and food-gift-giving as a form of "*merit minded*" charity was practised occasionally as well (in Buddhism, "making merit" refers to good acts that generate positive karma and contribute to a better life after rebirth). However, food solidarity was threatened by individualisation and market expansion: "*When we went hunting and could kill something, we would come back to share. But now, the community has been infiltrated by an outside economic system. You would need to exchange using money*" (Thai Site 4, male). Remaining sharing practices thereby evolved along the aforementioned ideal of the "deserving poor," where small food gifts were "*fine if it is not too much*" (Lao Site 1, female) but often linked to demonstrations of effort or deservingness: "R: *You can come to help in my garden.* […] R: *When you come, we give you food, also give you some money*" (Lao Site 2, male).

The presence of food solidarity and sovereignty underscored the temporal and social dynamism of the food environment: They evolved in constant interplay and tension with the expansion of the market-based food environment. This dynamic (which can be interpreted as "foodways") did not only shape the face of local foodscapes, but it also rendered them political spaces in which communities and sub-communities would assert their social values. While the tension was visible in both urban and rural sites, it was especially pronounced in the rural study settings experiencing environmental degradation, and yet more in the Indigenous communities being exposed to top-down rural transformation agendas (see more below in the final theme).

### 4.4. Food environments in the human security context

The final major theme was the relationship between food and nutrition security and the broader human security concerns afflicting the study communities. Human security considerations pertain to economic, food, health, environmental, personal, community, and political threats to people's dignity, livelihood, and survival (Commission on Human Security, 2003; UNDP, 1994:24–25). The previous section has already highlighted some of these challenges (e.g. poverty and temporary financial constraints preventing market access), but subtle threats to people's dignity and recognition could undermine food security as well. One such challenge arising in the Thai sites was the ambiguity of state aid for Indigenous peoples who faced continued institutional discrimination (also see Sakboon, 2007), which discussion participants expressed as pessimism about state support ("*I haven't received the government welfare card yet, I don't know if I will get it or not*," Thai Site 4, female). Another aspect with ethnic inflections was the issue of inclusion and assimilation. Highlanders who migrated to lowland areas in urban

Thailand found themselves confronted with a food environment that precluded the free movement that their original community afforded, which left them "*afraid*" and "*not comfortable going to the area that we don't know*" (Thai Site 2, Hmong, female). The relocation to the urban setting thus meant a fundamental lifestyle adjustment that required them to suppress their Indigenous identity:

> *Coming down here, we have to change our way of life to be more like the people here as much as possible. We can't ask a lot from them. We have to grow our own* [vegetables] *or if we can't grow, we have to go and buy.* (Thai Site 2, Hmong, female)

Another threat to dignity and inclusion raised in both sites was isolation experienced by older people. Respondents would cite cases of old and isolated villagers living in poverty, explaining that, "*her husband died, her children don't look after her*" (Lao Site 3, female) and that children and grandchildren no longer took care of their older relatives living alone in a village. The practical extent of this challenge went so far that older study participants repeatedly stressed the futility of including them in food environment research: "*You have to track people who go places often. For me, I only stay at home and I don't go anywhere*" (Thai Site 2, Khon Mueang, female).

This final theme emphasised a shift in perspective away from individuals and their practices in the food environment, to the broader contextual stressors that impacted food-related behaviour and insecurity – and which constituted salient elements in people's lived experiences. Contextual issues such as precariousness, ethnic discrimination, and social isolation shaped specific food practices and the interplay between food solidarity and inclusion in the market-based food environment.

## 5. Discussion

Responding to persistent global food and nutrition security challenges alongside gaps in understanding the lived experiences of food environments, this paper aimed to capture communities' views of food environments, how they navigate these spaces, and what constitutes inequitable exclusion therein. Based on research with 90 focus group participants in 16 rural and urban communities in northern Thailand and northern Lao PDR, we found that:

a) diverse and dynamic local foodscapes require careful study to understand relevant actors and sites in food environment research and to inform dietary diversity assessments;
b) the social dimensions of the food environment shaped food-related behaviour across gender and ethnic groups and with strong interpersonal elements such as food sharing and competition;
c) food security found local expression in food sovereignty and food solidarity – which stood in continued and evolving tension with the expanding market-based food environment; and
d) food-related behaviour was deeply embedded in a broader human insecurity context that comprised for instance issues of precariousness, ethnic discrimination, and social isolation.

These four themes map onto review findings that informal markets and social factors mediate access and resilience in the region (Rousham et al., 2023) and echo insights from open-ended qualitative and participatory food environment research in Thailand and Lao PDR that has documented the social constructions of food environments and everyday relational dynamics therein (Kounnavong et al., 2025; Zeitler et al., 2025), charted interconnections between livelihoods, power, and practice (Dwiartama et al., 2023; O'Meara et al., 2024; Rizaldo et al., 2024), advanced political notions of autonomy and food sovereignty (Dwiartama et al., 2023), and underscored gendered experiences for instance in restricted mobility of women in the physical food environment (O'Meara et al., 2025).

Social and experiential complexities as documented here also create food-related practices that are prone to be missed by standard dietary assessment tools, which speaks to measurement gaps that have been flagged in systematic reviews (Gilcharan Singh et al., 2024). Methodological approaches building on external assessments of physical food environments (e.g. based on GIS) are similarly susceptible to ignoring complex and situated practice as had been highlighted by Mattioni et al. (2020). For example, our study has shown that older and disabled individuals may still access the food environment through food delivery services or help from their family members, which indirectly expands their reach through (though not equitably distributed) social and technological means. Traditional spatial GIS-based food environmental studies have tended to draw somewhat strict boundaries of physical spaces, which makes it difficult to account for and incorporate such socially and technologically conditioned practices that partly extend into virtual spaces. This study therefore contributes not only empirically to the understudied contexts of Thailand and Lao PDR, but also reinforces the conceptualisation of food environments as dynamic, relational, and socially constructed spaces.

The simple notion of social and physical food environment activity spaces is consistent with the four themes of our study and aligns with the behavioural and structural considerations of food practices in the sociological foodways literature (Alkon et al., 2013; Chan, 2025). This open-ended analytical framing has the potential to guide further research on the exclusion from food environments and the outcomes in terms of nutrition, dietary quality, and food security. Following our analysis, the first question to guide the analyst would be to ask, "What is 'food' for the relevant target populations?" As our study has indicated, food environments vary even across nearby communities within the same province, which has implications for how we understand relevant food behaviour (see e.g. Mintz and Du Bois, 2002; Schunko et al., 2022). For example, different types of food such as fish, herbs, or dietary supplements circulate differently through the social and market-based relationships within the food environment and thus come with their own patterns of exclusion and inclusion. While there has been a drive towards standardisation of dietary quality assessments such as the *Measuring What the World Eats* report is laudable (and local adaptations can be made relatively easily; Global Diet Quality Project, 2022), omissions and the lack of local perspective on the boundaries and actors of food environments can also undermine the usefulness of such assessments as outcomes of exclusion.

Secondly, food environment activity spaces treat food-related practices as intrinsically social and dynamic. For example, considering that the social space is populated by other food seekers, competition and collaboration between them shape food access patterns – and consequently forms of exclusion that purely physical perspectives may not be able to detect (Marwa et al., 2021; Osei-Kwasi et al., 2020; Plue et al., 2020). The relationships between these actors and the broader context are also continually in flux (see e.g. Boncyk et al., 2022; Britwum and Demont, 2022:5). This social and dynamic activity space thus requires grounded exploratory research before describing (and mapping) it quantitatively (e.g. if providers of food are mobile, operate outside of structured markets; see e.g. the discussion in Muzenda et al., 2022). Following the grounded research to define them, activity spaces can potentially serve as systems map to define and modify levers for changing food-related behaviours (using e.g. the COM-B and MINDSPACE frameworks to describe cognitive, individual, and contextual drivers of behaviour; Dolan et al., 2012; Michie et al., 2011). Likewise, economic modelling of food-related practices including competitive and collaborative behaviour and knock-on effects in this system (see e.g. Dolan and Galizzi, 2015) can potentially yield new insights into the viability of nutrition interventions and distributive implications of changes in the food environment.

Thirdly, research that is unwittingly shaped by ideologies whose underlying assumptions drive food insecurity may produce recommendations that seek to address "exclusion" from the food environment through the very same market-based mechanisms that contribute to inequitable food access (e.g. the NOURISHING framework described in

Drewnowski et al., 2020; Hawkes et al., 2013; or otherwise proposals of e.g. simply improving availability of healthy foods as suggested by Li and Kim, 2020; Westbury et al., 2021). By giving voice to people's lived experiences and their historical antecedents, activity space analyses help question the existing technologies, solutions, and rules that govern food-related practices (anthropologists are commonly concerned with these issues; Mintz and Du Bois, 2002). The activity space approach to food environments thus resonates with calls to acknowledge deeper cultural and Indigenous dimensions of food environments in light of food sovereignty (Britwum and Demont, 2022; Calderon Farfan et al., 2023).

Lastly, the grounded approach to lived experience research within activity spaces also draws attention to the ethical responsibilities of researchers studying food environments. For example, our study participants in Thailand suggested physical movement tracking with mobile phones or GPS tracking devices could affect them adversely if they were being questioned by conservation authorities and accused of trespassing of protected areas: "*we didn't do anything, but people might think otherwise*" (Thai Site 4, male). Even on non-conservation lands in Lao PDR, such movement tracking might lead to conflict: "*like when you* [carry a tracker and] *go to a garden or farm, what do you do? Do you go and steal?*" (Lao Site 1, male). Although geospatial tools are being increasingly used to map food environment configurations and movements in local "neighbourhoods" (Ambikapathi et al., 2021; Muzenda et al., 2022; Plue et al., 2020; Wei et al., 2023), researchers need to carefully weigh the costs and benefits of these methods in close consultation with study communities.

It is important to contextualise these arguments. Firstly, the regional focus on northern Thailand and Lao PDR means that conceptualisations of food and the local configurations of the food environment that fed into our analysis were influenced by the cultures, histories, and political context of the study sites (see e.g. the different contexts of Ambikapathi et al., 2021; Downs et al., 2022; Lucan et al., 2013; also see Westbury et al., 2021). Secondly, our qualitative enquiry foregrounded community members' role as food consumers in the food environment, rather than food producers or vendors. However, in practice (including in our study and the reported material) these roles were not strictly separate. Thirdly, the discussion-, activity-, and recall-based data in our study opened important but also limited channels into people's lived experiences. Future research can complement these perspectives through immersive ethnographic research using participant observation techniques to capture the real-time navigation of food environments.

## 6. Conclusions

This paper makes an important bottom-up contribution to the study of lived experiences of – and potential solutions for – food environment challenges in low- and middle-income contexts. Our work draws again attention to the well-understood limitations of global nutrition and dietary quality assessment tools. While scholars and practitioners are aware of the need for cross-cultural adaptation of such tools, our study highlights that "cross-cultural" adaptation may require considerably more granular perspectives in settings such as Thailand that comprise a high diversity of Indigenous communities, migrant cultures, and seasonal foods (as also highlighted in research in rural Lao PDR by Rizaldo et al., 2024). Work towards a comprehensive catalogue of dietary quality would also require a better mapping of food environment dynamics (e.g. across seasons and taking account of festivals) than is presently the case in sentinel studies. Further practical considerations relate to food environment-oriented interventions to improve food security and nutritional outcomes.

While several proposals exist (Drewnowski et al., 2020; Hawkes et al., 2013; Li and Kim, 2020; Westbury et al., 2021), further research towards the lived experiences of food environments as social and physical activity spaces can foster new research and interventions that are sensitive to local realities and conscious of broader interactions between food environments and their human security context (consider e.g. systemic action similar to nutrition-sensitive agriculture interventions, Ruel et al., 2013). Possibilities in this direction – based on the themes in our research – could for instance (a) address movement in the food activity space by ensuring that healthy food options can reach mobility-impaired and older population groups (e.g. the common vegetable trucks loaded with market produce and roaming local streets in Thailand), (b) support food activity spaces contextually through occupational legislation that reduces precariousness and time pressure in people's jobs to enable sufficient time for food preparation (e.g. enforcement of maximum working hours), or (c) interventions sensitive to the importance of community solidarity or food sovereignty to achieve food security (e.g. government support of land and capital for community-based agricultural production and consumption). Future research on food environment activity spaces (lived experiences and otherwise) therefore holds great promise in advancing our understanding of global and local food security and context-sensitive food environment interventions.

## Ethical approval

The research had been reviewed and approved by the University of Reading School of Agriculture, Policy and Development Ethics Committee (ref. 1961D) and the Lao PDR University of Health Sciences Research Ethics Committee (ref. 395/REC). Chiang Mai University Research Ethic Committee waived separate review requirements following approval from the University of Reading.

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## CRediT authorship contribution statement

**Marco J. Haenssgen:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Supervision, Visualization, Writing – original draft, Writing – review & editing. **Nutcha Charoenboon:** Formal analysis, Investigation, Methodology, Project administration, Supervision, Writing – review & editing. **Thipphaphone Xayavong:** Data curation, Investigation, Project administration, Supervision. **Toum Lathsamee:** Project administration. **Prasit Leepreecha:** Investigation, Project administration, Resources, Supervision, Writing – review & editing. **Eric Deharo:** Project administration, Resources, Supervision, Writing – review & editing. **Giacomo Zanello:** Conceptualization, Funding acquisition, Investigation, Supervision, Writing – original draft, Writing – review & editing. **Chittur S. Srinivasan:** Conceptualization, Funding acquisition, Investigation, Project administration, Supervision, Writing – original draft, Writing – review & editing.

## Declaration of competing interests

We declare that no conflict of interest – financial or otherwise – exists.

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## Appendix A. Supplementary data

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## Data availability

Data will be made available on request.

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