

MASTER'S THESIS

COMPARATIVE STUDY : ASSESSING NUTRIENT INTAKE ADEQUACY AND DETERMINANTS OF EATING BEHAVIORS ACROSS COMMUNITIES IN BARDIYA DISTRICT, NEPAL



Resting in the Golden Fields (*Emma Opitz, 2024*)

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Abstract

Exposing the complex and intricate relations between dietary patterns and socio-demographic and economic factors, this research study aims to uncover the nutritional discrepancies and challenges faced by pregnant and breastfeeding women in marginalized communities in the Mainapokhar Village, Bardiya District, Nepal. Focusing on the differences between Mukta-Kamaiya (freed bonded-labourers) and non-Mukta-Kamaiya communities, the study exploited retrospective data collection approach gathered through a cross-sectional among a convenience sampling population of 61 women. The survey was divided into a 24-hour dietary recall and an individual, household and eating habits questions survey. Nutrient intakes, dietary diversity and eating determinants were assessed, scored and compared between the two specific groups.

The results of this study showed notable differences between the Mukta-Kamaiya and non-Mukta-Kamaiya women, with lower nutrient adequacy for proteins, fibers, calcium, iron, magnesium, copper and various vitamins for Mukta-Kamaiya. Moreover, 66% of them faced a non-adequate dietary diversity with an average score of 3.9 out of 10 compared to 4.9 for the non-Mukta-Kamaiya women. This lower score was associated with limited consumption of certain groups, including pulses, dairy products, meat, eggs and fruits. Both groups sufficiently or excessively consumed certain nutrients, such as sodium, fats, proteins, magnesium and selenium.

On another hand, only wealth and educational level were found to positively influence dietary diversity and nutrient intakes for non-Mukta-Kamaiya, with no correlations noticed for Mukta-Kamaiya women. This underpinned that nutritional choices and status are framed by a multitude of factors, challenging the significant establishment of relationships between specific variables and dietary ones. However, it was identified that food affordability remains a limiting factor for the Mukta-Kamaiya, although without statistical confirmation. This challenge is intensified by the small size of their agricultural plots and certain government policies. In addition, without differences between the two groups, eating determinants as the influence of in-laws, food taboos and eating habits were found to further limit dietary diversity.

Consequently, the overall results urged the need for implementing location and population-specific nutritional interventions to address the unique context of marginalized people, such as Mukta-Kamaiya.

Résumé

Soulignant les relations complexes et intrinsèques entre les habitudes alimentaires et les facteurs socio-démographiques et économiques, ce stage de recherche vise à démontrer les différents défis nutritionnels auxquels sont confrontées les femmes enceintes et allaitantes dans les communautés marginalisées du village de Mainapokhar, dans le district de Bardiya, au Népal. L'étude se concentre plus particulièrement sur la situation des Mukta-Kamaiya, anciens travailleurs exploités, libérés dans les années 2000. Cette recherche est une étude préliminaire demandée par la FAO (Organisation des Nations Unies pour l'alimentation et l'agriculture) dans le cadre de la mise en œuvre de son projet *d'Assistance Technique pour l'Amélioration de la Sécurité Alimentaire et Nutritionnelle par la Génération de Revenus Diversifiés et l'Autonomisation*, dont le lancement est prévu pour la fin de 2024. Ce dernier cherche à améliorer le statut nutritionnel des femmes enceintes et allaitantes, ainsi que des enfants de moins de cinq ans, dans la zone bénéficiaire.

Face à la nécessité de développer un projet adapté aux populations ciblées, il est essentiel d'étudier les dynamiques nutritionnelles des femmes Mukta-Kamaiya en comparaison avec celles d'autres communautés. Les résultats de cette étude permettront d'ajuster les interventions du projet aux besoins et défis rencontrés par cette population. Ainsi, la problématique principale est la suivante: *Les femmes enceintes et allaitantes de la communauté Mukta-Kamaiya rencontrent-elles des dynamiques nutritionnelles différentes par rapport aux autres communautés ?* Afin de répondre à cette dernière, trois hypothèses ont été formulées : i) les femmes enceinte Mukta-Kamaiya présentent plus de déficiences nutritionnelles ; ii) elles ont une diversité alimentaire plus faible par rapport aux autres communautés et ; iii) les déterminants alimentaires sont distincts entre les deux groupes étudiés.

Pour approfondir ces hypothèses de recherche, une étude bibliographique a permis d'identifier les facteurs majoritaires influençant la nutrition des femmes, enceintes et allaitantes, dans district de Bardiya et plus exactement au sein de la communauté Mukta-Kamaiya. L'histoire de cette communauté, issue de l'ethnie Tharu des plaines népalaises, a eu un impact important sur leur alimentation. Caractérisés par une dépendance envers leurs maîtres, qui leur fournissait des portions rationnées, leurs régimes alimentaires étaient principalement composés de riz. Leurs conditions de vie étaient très difficiles, marquées par une dette qui les reliait aux maîtres et dont ils ne pouvaient pas s'émanciper. En effet, leur seule manière pour subvenir à leurs besoins nutritionnels consistait à demander davantage d'argent ou de nourriture, ce qui ne faisait qu'aggraver leur endettement.

De plus, l'ethnie Tharu, dors-et-déjà marginalisée au sein du système de castes népalais, a, toujours aujourd'hui, un accès limité aux institutions, infrastructures et est faiblement représentée politiquement. Plus généralement, les populations le Terai, région frontalière avec l'Inde, sont

fréquemment mis à l'écart et présentent des taux de malnutrition plus élevés que dans d'autres régions du pays. Les femmes de cette région sont souvent isolées, socialement et au sein des ménages, avec un pouvoir de décision et une liberté restreints. Elles mangent fréquemment en dernier, après les autres membres du foyer, empêchant une alimentation aussi bien en termes de quantité qu'en qualité.

La condition des femmes dans les plaines du Népal, combinées à celle des Tharu et des Mukta-Kamaiya, exacerbe encore la vulnérabilité des femmes enceintes et allaitantes de cette communauté d'anciens travailleurs. Néanmoins, leurs conditions sont également influencées par l'environnement, notamment par l'accessibilité, l'abordabilité financière, la désirabilité et la disponibilité des produits alimentaires. En effet, bien que le district de Bardiya produise suffisamment de cultures pour subvenir à ses besoins, il doit pareillement approvisionner d'autres régions du pays, dont la production ne couvre pas la demande alimentaire. De plus, les régions frontalières avec l'Inde dépendent des importations indiennes et sont soumises à la fluctuation des prix du commerce international. Globalement, si de nombreux produits alimentaires sont disponibles dans le district de Bardiya, leur abordabilité et leur désirabilité restent des enjeux complexes. En effet, les salaires sont faibles et les habitudes alimentaires népalaises se limitent à certains produits et sont centrées sur le riz, alors que légumineuses et légumes sont consommés en petites quantités, rendant l'alimentation peu variée et souvent déficiente en nutriments essentiels. En somme, les déterminants alimentaires identifiés sont interconnectés et se répartissent en facteurs économiques, démographiques, physiques, biologiques et sociaux, ces derniers comprenant l'appartenance à une communauté, les dynamiques au sein du ménage, les rôles liés au genre et les habitudes alimentaires.

Afin de comprendre le contexte des Mukta-Kamaiya et répondre à la question de recherche, une étude rétrospective a été mise en œuvre auprès d'un échantillon de convenance de 61 femmes dans le village de Mainapokhar (district de Bardiya), dont 30 Mukta-Kamaiya et 31 issues d'autres communautés afin de les comparer. Chaque groupe comprenait 15 femmes enceintes et 15 femmes allaitantes. L'enquête a été divisée en deux parties : un rappel alimentaire de 24 heures et un questionnaire sur les caractéristiques sociodémographiques, économiques et alimentaires des participantes, afin d'analyser certains déterminants identifiés au cours de la phase de contextualisation de l'étude.

La collecte des données, réalisée en une semaine au début du mois de mai, a été conduite avec l'aide de quatre enquêteurs népalais et trois interprètes Tharu. Les données alimentaires ont été collectées selon la méthodologie spécifique du rappel de 24 heures avec l'aide d'instruments, incluant une liste des plats et aliments consommés dans le Terai et un atlas des portions de ces éléments.

Finalement, ces codes de portions et de plats ont été convertis en nutriments consommés par jour grâce à une table de composition alimentaire. Les apports ont été comparés aux recommandations de la FAO. La diversité alimentaire a été évaluée selon l'indice MDD-W (Minimum Dietary Diversity for Women), basé sur la consommation d'au moins 15 grammes de chacun des 10 groupes alimentaires retenus. En parallèle, certaines données provenant de la deuxième partie des entretiens ont été évaluées, notamment en ce qui concerne les indicateurs de pouvoir de décision au sein du ménage, des dynamiques alimentaires, de l'insécurité alimentaire vécue et de la richesse traditionnelle. Enfin, l'ensemble des informations a été traité et analysé avec le logiciel SAS afin de comprendre les disparités entre les groupes étudiés et l'influence de divers indicateurs sur les niveaux nutritionnels.

Les résultats indiquent de significantes différences entre les femmes Mukta-Kamaiya et non-Mukta-Kamaiya. Les premières présentent une adéquation nutritionnelle inférieure pour les protéines, les fibres, le calcium, le fer, le magnésium, le cuivre et diverses vitamines. Aussi, 66 % d'entre elles ont une diversité alimentaire non adéquate avec un score moyen de 3,9 sur 10, contre 4,9 pour les femmes non-Mukta-Kamaiya. Ce score inférieur est associé à une consommation limitée de certains groupes, notamment les légumineuses, les produits laitiers, la viande, les œufs et les fruits. Les deux groupes consomment suffisamment ou excessivement certains nutriments, tels que le sodium, les graisses, les protéines, le magnésium et le sélénium. La consommation de riz s'est avérée prépondérante, représentant 60% de l'apport calorique chez les Mukta-Kamaiya et 50% chez les autres communautés.

De plus, seuls la richesse et le niveau d'éducation ont semblé influencer positivement la diversité alimentaire et les apports en nutriments chez les femmes non-Mukta-Kamaiya, bien que aucune corrélation n'ait été observée pour les femmes Mukta-Kamaiya. Cela met en lumière que de multiples facteurs influencent les choix nutritionnels, rendant difficile l'établissement significatifs de relations entre certaines variables et le statut alimentaire. Sans confirmation statistique évidente, il a pourtant été identifié que l'abordabilité des aliments constitue un facteur limitant de la consommation chez les Mukta-Kamaiya. Ce problème est intensifié par la taille limitée des parcelles agricoles, les faibles rémunérations, et certaines politiques gouvernementales empêchant l'investissement dans divers secteurs hors de l'agriculture. Par ailleurs, d'autres facteurs, tels que l'influence des belles-familles, les tabous et habitudes alimentaires, réduisent davantage la diversité alimentaire, toute communauté confondue. Leur perception de l'adéquation de leur régime vis-à-vis de leurs besoins nutritionnels révèle un manque de connaissance en matière de nutrition et ainsi un besoin accru de sensibilisation.

En conséquence, les résultats finaux ont souligné la nécessité de mettre en œuvre des interventions nutritionnelles adaptées à la localisation et à la population afin de répondre au contexte

unique des personnes marginalisées, telles que les Mukta-Kamaiya. Afin d'améliorer la condition nutritionnelle des plus vulnérables, il s'agirait d'agir conjointement sur une multitude de facteurs qui conduisent à cette précarité.

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List of Abbreviations and Acronyms

BCC - Behaviour Communication Change

BMI – Body Mass Index

CLT – Central Limit Theorem

CoRD – Cost of a Recommended Diet

FAO - Food and Agriculture Organization

FBDG – Food Based Dietary Guidelines

FIES - Food Insecurity Experience Scale

FCS – Food Consumption Score

FHI – Family Health International

GASP - Global Agriculture and Food Security Programme

HDI - Human Development Index

HNG - Home Nutrition Gardens

ICMR – Indian Council of Medical Research

IFPRI - International Food Policy Research Institute

MAR – Mean Adequate Ratio

MDD-W - Minimum Dietary Diversity for Women

MK - Mukta-Kamaiya

NACCFL - Nepal Agricultural Co-operative Central Federation

NAR – Nutrient Adequacy Ratio

NDHS - Nepal Demographic Health Survey

NFS - Nutrition Field Schools

NGO – Non-Governmental Organization

NPR – Nepalese Roupee

OMCT - World Organisation Against Torture

PCA – Principal Component Analysis

PO – Producer’s Organization

RDA - Recommended Dietary Allowance

RF – Retention Factor

SAS - Statistical Analysis System

SNG - School Nutrition Gardens

UNICEF - United Nations International Children's Emergency Fund

WDDP - Women's Dietary Diversity Project

WFP - World Food Programme

WHO - World Health Organization

YF – Yield Factor

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Figure 1- Data Collection Field Team (Emma Opitz, 2024)

Introduction

All around the world, it is commonly known that a child's survival and growth chances are already determined before their birth. The United Nations International Children's Emergency Fund (UNICEF) communicates that poor diets during pregnancy can cause several health issues for both mothers and children. Thus, breastfeeding and pregnant women play the most important role for the future of generations' health with women's well-being and nutrition being vital during the first 1000 days of a child's life as it influences parts of their lifelong health. Nevertheless, many low- and middle-income countries' population do not meet nutritional needs due to multi-sectorial challenges: food availability and accessibility issues, cultural practices, economic and socio-demographic factors.

Maternal and child health is a worldwide priority, as demonstrated by the Sustainable Development Goals (SDG), aiming to reduce global maternal mortality of newborns and children under 5 years old. Responding to this primary issue, international organizations, such as the Food and Agriculture Organization (FAO) launch valuable projects to address it. Such a vital project has been elaborated in the western Terai region of Nepal, in the Bardiya District, by FAO Nepal, titled *the Technical Assistance to Improved Food and Nutrition Security through Diversified Income Generation and Empowerment* project. This project, among other themes, focuses on contributing to the cause of pregnant and lactating women from an indigenous Tharu community, that were previously bonded labourers (Mukta-Kamaiya).

This thesis aims to understanding the nutritional dynamics in the Bardiya District, comparing those of marginalized Mukta-Kamaiya (MK) community to those of other communities. This comparative study will attempt to answer to this question: *Do pregnant and lactating women from the Freed-Kamaiya Community experience different nutritional dynamics compared to other communities?* It will investigate the differences in nutrient adequacy and food groups consumption patterns between Freed-Kamaiya women and those from other communities, and the impact of community affiliation on eating determinants.

This thesis will begin with an overview on the broader context, including the food security status, the socio-economic position of Mukta-Kamaiya and the nutritional needs of pregnant and breastfeeding women. The Bardiya District environment and dietary patterns will also be included. The methodological framework of the data collection and analysis will be presented and support the following findings, which will be discussed. The final part of the thesis will address the limitations faced.

I. Mukta-Kamaiya Women: A Study on Food Security and Nutritional Challenges

1.1 Food Security and Nutrition: Global and National Issues

Since 2023, hunger prevails as a major global challenge, despite its stabilization in Asia, diminution in Latin America and rise in Africa, and is intensified by the impacts of climate change. In 2022, it has been evaluated that one-third of the global population was unable to afford a healthy diet, with this issue being most prevalent in low-income countries. Therefore, achieving the SDG of zero hunger in the world by 2030, seems unlikely. It was predicted by researchers that in 2030, around 582 million of people will be chronically malnourished, especially in Africa. However, progress has been noted in reducing stunting and wasting for children under 5 years old and improving breastfeeding practices for infants under 6 months after birth (FAO et al., 2024).

Pregnant and breastfeeding women, along with children, continue to be the most vulnerable population to food insecurity, facing disproportionate trouble of malnutrition due to their specific nutritional requirements (Corley, 2021). These groups hold less decision-power and face restricted access to resources within households, leaving them with limited tools to ensure they meet their own needs. Moreover, they must follow cultural norms, disadvantaging their health. On this basis, dietary habits worldwide are shaped by several factors, formally called determinants of food choice. They can be categorized in biological, physical, economic, social, psychological and beliefs-related determinants (Shepherd, 2007).

In Nepal, a country classified as least developed and landlocked between India and the Tibet Autonomous Region of China, progress has been made to reduce food insecurity over the last decade. However, the country's is still facing isolation and dependence on limited agriculture and landownership, affecting the living conditions and food security of its 30 million residents. Remarkably, trends of malnutrition, stunting and undernourishment showed a constant decrease in 2019 compared to 2015 (Government of Nepal, 2019). Despite Covid-19 and Russia-Ukraine related challenges, the proportion of Nepali people not consuming an adequate diet was lower (13.2%) in June 2022 than at the start of the pandemic. Dietary diversity improved, with 99.8% of the population having an acceptable diet. These improvements in dietary patterns were also seen in April 2023, with a 2.2% food insecurity decrease compared to October 2022 (World Food Programme, 2023). Nevertheless, with the increasing globalization, the country faces the double burden of malnutrition, with co-existing macro and micronutrient deficiencies and increase of obesity and overconsumption rates.

These global and national improvements are the results of collective efforts across diverse sectors, including agriculture, education, economic growth, access to resources, and critical support of the government and international organizations (FAO et al., 2024).

1.2 Emergence of the Study Topic

Since the mentioned global and national efforts demonstrated efficiency in tackling nutrition challenges, it has become essential to elaborate specific projects shaped for local contexts. Hence, this thesis' had to be aligned with FAO Nepal nutrition-related initiatives, particularly a project implemented by the Nepal Agricultural Co-operative Central Federation (NACCFL) aiming to address the challenges faced by vulnerable communities in the Bardiya District.

1.2.1 Demand Context: FAO and NACCFL Project

The “Improved Food and Nutrition Security through Diversified Income Generation and Empowerment Project”, also referred to as the NACCFL Project, a Global Agriculture and Food Security Programme (GASP) funded project, should start in the end of 2024 and end in 2027 (NACCFL Project Concept Note, 2024).

Five components are allocated to this project: increase household income, improve the score on the Food Consumption Score (FCS), improve the dietary intake for pregnant and nursing women, and children between 6-and 24-months, increase the number of people receiving direct benefits as well as the land area with climate resilient or sustainable agriculture practices. These components are targeting 8593 total beneficiaries, among which 75% are women and 55% are from the Tharu Community that can be found in Mainapokhar, Padnaha, Kalika, Deudakala, and Basgadhi villages in Bardiya district of western Nepal. It is crucial to highlight that many of the Tharu community were following the Kamaiya-system until July 2000, a traditional form of slavery. Despite the abolition of this bonded-laborers system, the Tharu ethnic group still today must face poverty and land ownership issues. These clear issues, interlinked with their history as bounded laborers, have brought forward the question of nutrition availability and intake sufficiency within these communities.

For achieving the project's objectives, the interventions will promote household nutrition by implementing Home Nutrition Gardens (HNG), School Nutrition Gardens (SNG), Nutrition Field Schools (NFS) and other nutrition-related activities. For these activities, the curriculum proposed by the FAO must be adapted, to better understand local norms and behavioural habits. Creating a location and population-specific project would facilitate the identification of opportunities for increasing nutrition knowledge and change rooted habits to promote more nutritious diets.

1.2.2 Objectives, Research Question, and Hypotheses

To address this need of a comprehensive understanding of local characteristics, the thesis aims to give a nutritional assessment of the marginalized indigenous Tharu community, specifically the freed-Kamaiya and focus pregnant and lactating women, targeted by the NACCFL project. Understanding the food security level of freed-Kamaiya individuals requires consideration of external

factors influencing their eating behavior and habits. These include household socio-demographic status, dynamics, as well as the availability, affordability, accessibility and desirability of foods, and major eating habits and traditions. Thus, these considerations lead to the formulation of the research question: **Do pregnant and lactating women from the Freed-Kamaiya Community in the Bardiya District experience different nutritional dynamics compared to other communities?**

The term nutritional dynamics is used here used to visualize a broad range of factors, including nutrient intake, dietary diversity, and determinants of food choices. These concepts are linked to the following hypothesis that this thesis aims to study:

- There is a disparity in nutrient adequacy dynamics between the two communities, with a higher prevalence of deficiencies observed in the Mukta-Kamaiya Community.
- Freed-Kamaiya women exhibit a lower MDD-W score compared to women from other communities.
- The determinants of women's food consumption vary based on their community affiliation.

1.3 Role of Mukta Kamaiya

The Mukta-Kamaiya, meaning freed-Kamaiya, are the central part of this research-internship, in response to the FAO Nepal request. They represent a marginalized community found in the western Terai Region. Their status is shaped by both caste system and historical bonded labour practices present in Nepal, which illustration enables a more comprehensive analysis.

1.3.1 Reminder of Castes and Ethnicities of Nepal

Nepal, such as India, has a complex caste system influencing the population's identity, social status and opportunities (Bennett *et al.*, 2008). Castes are not only defined by the ethnicity, but also by historical social hierarchy, religion, and regional differences. More specifically, ethnic groups are a consequence of colonial influence and state-building periods of Nepal (Giri, 2020) and influenced by the trading routes crossing the country. As a result, cultural interactions with Tibet, India and Central Asia increased and established the Indo-Aryan caste system.

Nepal encompasses 142 ethnicities, according to the National Population and Housing Census of 2021, with different festivals and rituals. The population practices a variety of religions, with Hinduism (81% of the population), followed by Buddhism (9%), Islam (4%), indigenous ethnic religions (3%), Christianity (1%), and others (International Centre for Law and Religion Studies, n.d.). Across ethnicities and religions, they all share a common culture and practice endogamy, marrying within their castes. Within these castes discriminations exist leaving marginalized groups deprived of resources and bringing societal tensions.

More precisely, the 1854 Muluki Ain (National Legal Code) defined a caste hierarchy, in order to consolidate the people under the country's authority, which was deeply influenced by Hindu law presented under the King Prithvi Narayan Shah. The population, Hindu or not (Bennett et al., 2008), was categorised based on purity and pollution, closely associated with the Varna System in Hinduism (Höfer, 1979). This discrimination had its importance in the legal and social policies of the country. However, it is worth mentioning that there is no formal caste definition (Parmar *et al.*, 2021), making the country's population classification into a hierarchical system and castes subjective to the source.

This caste hierarchy traditionally divided people into "Water Acceptable" (pure) and "Water Non-Acceptable" (impure) (Gurung, 2002). The "*pure*" groups included the "upper caste", composed of Brahmans and Chhetri from the hills, Newar from the Kathmandu Valley and Madhesi from the Terai region. It also gathered the "non-enslavable" groups, with the Gurung, Magar, Sunuwar, Thakali, Rai, Limbu and other Newar, from both the hill region and Kathmandu Valley. Finally, there are the "enslavable" ethnicities like the Bhote and Tharu groups, among others. On another hand, the "*impure*" category was divided into the "touchable" ethnicities and the "untouchable", gathering 14 ethnic groups. More recently, the 2001 Census provided another perspective on the main castes by including the regional inequities and the marginalized people from the regions bordering with India (Terai/Madhes) (Bennett *et al.*, 2008). Particularly, this social stratification put emphasis on the *Janajati* ethnic groups from Terai and Madhes, bringing forward their special social status.

Janajati, including Adivasi, are indigenous people, with distinct cultural, linguistic and religious identity and are, according to this classification, considered differently than the hierarchical social structure. The Newar, considered Adivasi, are recognized as the privileged original inhabitants of the Kathmandu Valley, with a unique heritage, while other Janajati Groups like Tharu people in the Terai region, remain marginalized (Bennett *et al.*, 2008). The Dalits, Muslims and Madhesi groups face the same challenges as certain Janajati with lower economic well-being. Terai households have fewer possessions and access to public utilities than in the Hill or Mountain zones (Bennett *et al.*, 2008).

Women within caste groups are often the least considered, and very poorly included in Nepal society. Women from the Terai, Madhesi and Dalit communities show to be less educated and highly illiterate. The percentage of mothers who received antenatal care from a skilled birth attendant is one of the lowest for Terai Janajati women, which encompasses Tharu people (Bennett *et al.*, 2008).

Nevertheless, Nepal has been trying to tackle these discriminations these past decades with reforms and policies. The 2015 Constitution forbids any caste-based discriminations and introduces positive policies to improve the marginalized communities representativity in the government and

main institutions (International Labour Organization, n.d.). Despite these efforts, communities' re-insertion in the society is challenging and requires location-specific assessment of their situations.

This complex social hierarchy is further represented by the Kamaiya history, demonstrating how exploitation and marginalisation of certain groups was vicious and is still now difficult to rectify.

1.3.2 History of the Kamaiya System

The Kamaiya system was a long-time established bonded-labourer system majorly followed by the Tharu ethnic group. It referred to labourers that could not have power over their own labour force, due to "*political-ideological constraints or economic coercions*" (Brass, 1999). It involved doing field works and household chores for landowners. It represented a specific labour-relationship, often characterized by the repayment a loan, taken by the worker or his parents, from the owner.

The Kamaiya system was first described in history between 100 and 880 Anno Domini ¹ during the Lichhabi Dynasty but was legitimated during the reign of the King Jayashiti Malla of Kathmandu, end of the 15th century (OMCT, 2006). The most recent intensification of the Kamaiya system begun in the 1950's, when many migrants came into the Terai Plains, whom land-grabbed those traditionally in possession of the Tharu people, traditional inhabitants of the region, with the help of the government. As the Tharu did not have any official landownership titles, their only option to maintain access to resources was to work on their former lands for the new landowners. Kamaiya often had to take loans from these landowners to sustain livelihood, thus becoming indebted. This indebtedness bond forced them to work to repay the loans, in most of the cases. Despite technically having the choice to renew their verbal agreements annually, economic, social and political factors, pressured Kamaiya people to accept the master's conditions, similar as slavery (OMCT, 2006).

The living conditions of the Kamaiya was different according to the landowners and their status. Wealthier landowners were often considered the most demanding, while some Kamaiya who worked for other Tharu people were considered as almost equals (Personal Interviews, Mainapokhar Village Development Committee, May 2024). Whether or not the Kamaiya had a *Saunki* (debt), they were trapped in the vicious circle of working for their landowner without freedom, as they had lost all socio-economic resources and flexibility to provide for their families. Moreover, as the wages provided by the landowners were often insufficient to support the expenses for food, clothing, medications, wedding, death rituals and social obligations (festivals) for the entire family, the labourers were forced to borrow money and creating an initial debt, a *Saunki* (OMCT, 2006). Within Kamaiya families, women and children were assigned to tasks according to the *master's* needs, in the field or in the house.

¹ Refers to the years after the birth of Jesus

Kamaiya could not change landowners, unless the new *master* one could repay the debt to the previous one (OMCT, 2006).

In 2000, the number of Kamaiya people, counting all family members, was the highest in Kailali and Bardiya Districts, Western Terai, with 30 463 and 25 846 individuals respectively, according to the local non-governmental organization Backward Society Education. It is that same year that the multiple movements that had raised achieved their objective: the government outlawed the bonded labourer system the 17 July 2000 (OMCT, 2006). Unfortunately, the liberation given to the bonded labourers was not accompanied by the government, nor access lands and resources, sometimes obliging them to illegal continue working for their previous landowners. Their way to socio-economic freedom remains challenged without support from the government, NGOs and international agencies.

1.3.3 Mukta Kamaiya: Social Position and Economic Opportunities

More than two decades after the end of slavery in Nepal, the former Kamaiya are still one of the most socio-economically disadvantaged groups of the country (Khatrī *et al.*, 2015). In fact, in the early 2000s, Mukta-Kamaiya people were left without resources because of an inadequate support from the state. Many of them had to live in the fields, enduring poor health conditions, waiting for access to lands and livelihood.

Even today, Mukta-Kamaiya, although freed, continue to face the stigma related to their previous societal status, keeping them marginalized. While the government eventually allocated up to 5 khatta² of land per family, the size of the lands is often insufficient to meet their needs or enable economic development. Their employment opportunities are further limited by their houses being frequently isolated. An important number of Mukta-Kamaiya work on other people's land, aside of theirs, as unskilled daily-wage labour remains their primary source of income (Personal Interviews, Mainapokhar Village Development Committee, May 2024; Chaudhary & Maharjan, 2012). Several Mukta-Kamaiya households are landless and around 25% wait to be rehabilitated, often living in very poor temporary huts. In addition, certain lands given by the government are unproductive or vulnerable to climate variabilities and disasters (Chaudhary & Maharjan, 2012). Their limited access to the educational system restrains them from developing specific skills and accessing to better job opportunities, directly impacting their poverty levels and food security. In some more advantaged cases, men have found work abroad, particularly in India or Dubai, which improves the families' economic status (Personal Interviews, Mainapokhar Village Development Committee, May 2024; Chaudhary & Maharjan, 2012).

² Approximately 0.0126 Hectare.

Some government policies put at a disadvantage the freed-labourer community. When granting the lands to the Mukta-Kamaiya after their liberation, it was stipulated that they could not use the land as an assurance³ for bank loans, due to fear that they could lose the land, leading them back to an illegal labour system. This decision, while formulated to protect them, limits their financial freedom, restraining them to invest in other sectors and improve their socio-economic status by giving them a stable income (Personal Interviews, Mainapokhar Village Development Committee May 2024).

Nowadays, Mukta-Kamaiya families express scepticism regarding the government, feeling that the support given was insufficient for proper conditions of living (Personal Interviews, Mainapokhar Village Development Committee, May 2024).

While this section underpins the socio-demographic challenges of Mukta-Kamaiya from their liberation to recent days, it is essential to note that their current living conditions is strongly influenced by these factors. The historical insights of poor dietary practices have also left long lasting impacts and understanding these linkages are crucial to permit the sustainable development of this group's status.

1.3.4 Nutritional Challenges: Historical and Current Causes and Consequences

During the Kamaiya system, the nutritional needs of the bonded labourers were rarely met, resulting in an alarmingly poor diet. In fact, the food supply relied on the generosity of their masters. In most cases, these families were paid on an annual basis in goods and services, which were not sufficient for meeting their nutritional needs. Consequently, Kamaiya families had to request additional food grains to their master's, which was added to their accumulating debt (OMCT, 2006).

In several cases, masters chose to directly feed Kamaiya people, providing a predetermined and rationed quantity of food. As this quantity and quality of food was insufficient, Kamaiya needed to request more, further increasing their loan and thus debt. With their diet almost completely consisting of rice, lentils and sometimes vegetables, they had poor intakes of protein fats, vitamins and minerals, leading to micro and macro deficiencies. Moreover, most Kamaiya were labour-intensive workers, exacerbating the gap between their nutritional requirements and their actual food consumption (OMCT, 2006).

Traditionally, Kamaiya families were compensated for their work with lands before it was replaced by in-kind wages and food rations (OMCT, 2006). If the land provision had continued it could have improved the Kamaiya eating practices, since it would have allowed them to choose the food production for their needs and its usage.

³ asset ensuring a loan's repayment to the bank, also called collateral

The recognized malnutrition faced by Kamaiya families emphasised a deeply rooted systemic exploitation and despite the system being abolished, it did not guarantee any improvement of their nutritional status. Even 24 years after the system's abolition, the improvement of their dietary practices and of their socio-economic and demographic determinants remains uncertain.

In fact, over the past decade, it has been observed that most of the Mukta-Kamaiya families are food insecure and the poorest group in the districts where they live. Their income is often insufficient to buy food from the market and is unstable, depending on unskilled labour or on the earnings of one household member. Furthermore, July and August showed higher prevalences of food deficits due to monsoons, which decreases the working hours and deteriorates health status, leading to smaller wages and restrained purchasing power (Chaudhary & Maharjan, 2012).

A 2015 study reported that the frequency of overall undernutrition in the freed-Kamaiya community was higher than the national average and greater than that in the Mid-Western Terai districts of Nepal group. These scientists suggested that it could be the consequence of an overall poor socio-economic status and non-optimal feeding practices. Notably, this study showed as well that children born from mothers over the age of 24 years old were less likely to be underweight, suggesting the mother's experience and knowledge could have a positive effect on the child and on her own nutrition (Khatrri et al., 2015).

1.4 Position of Women

These ongoing nutritional challenges faced by the Mukta Kamaiya community are often exacerbated among the community's vulnerable groups, like pregnant and lactating women.

1.4.1 Nutritional Vulnerabilities of Pregnant and Lactating Women

Studying women's food intake and their eating behaviours is crucial, particularly during pregnancy and lactation, as it directly impacts the well-being future generations. In fact, nutritional needs increase significantly during these stages of life. For example, pregnant women must develop gestational weight, which varies between 11 and 16kg depending on their body mass index (BMI), to support development of the foetus, placenta, uterus, amniotic fluid, mammary gland, blood and adipose tissue, among other physiological changes (Jouanne *et al.*, 2021). Adequate micro-nutrient intake is indispensable for cellular and metabolic activities permitting a beneficial development of the foetus and, later, the composition of the breastmilk. For instance, among many nutrients, folic acid (vitamin B9) should be consumed for the brain and spinal cord development of the baby, while iron is crucial to produce haemoglobin and transport oxygen and reducing anaemia risks in the mother. Calcium permits the development of the child's bones, heart, nerves and muscles, and omega-3 fatty acids support the proper formation of the brain and eyes (Christian & Stewart, 2010). Moreover, it has

been estimated that the entire pregnancy duration requires a total of 60 000 kcal above the normal requirements (Sharma *et al.*, 2020).

Breastfeeding women often face inadequacies, prevalently observed in vitamins (B9, B12, A, D), minerals (calcium, iron, iodine) and in poly-unsaturated omega 3 fatty acids (Carretero-Krug *et al.*, 2024). The quantity and quality of breastmilk depends on the maternal diet; yet it was noted that during postnatal care, the attention is mainly focused on the newborn, overlooking the mother's diet. The possibility of pregnant and lactating women to meet their recommended intakes depends on multifactorial eating determinants, such as women's living conditions, nutritional-needs ignorance, beliefs, poverty, limited food availability (Sharma *et al.*, 2020).

More precisely, it has been observed that in the Terai Region, Nepal, more than a quarter of the overall women were found malnourished (BMI<18,5kg/m²), making them 20 times more likely to be malnourished than in the mountain regions (Bhandari *et al.*, 2016). This disparity suggests an even greater challenge faced by pregnant and lactating women in this area. It also raises important questions about the main reasons for differences in women's diets depending on their geographical location, and how these factors change according to other genders and populations. It also induces a reflection of whether the vulnerable position of women, particularly in areas like Bardiya, contributes to their compromised nutritional status. It is important to note that if overall women are significantly impacted by factors exacerbating malnutrition, the effects are even more pronounced for pregnant and lactating women.

1.4.2 Within Nepali Society and the Bardiya District

In Nepali Society, women face significant challenges, dictated by gender roles, influencing various aspects of their life, including dietary behaviour and food security. Deeply rooted traditions, valued as blessing from ancestors based on gender-based ideologies from the Hindu and caste systems, influenced economic policies and preserved patriarchy mechanisms (Adhirarki & Sharma, 2022). Despite some major steps for women's empowerment, such as the establishment of the National Women Commission (2002), women continue to struggle in the broader political and economic environment, due to deeply rooted beliefs and habits (Acharya, 2020).

Even today household dynamics often restrain women's decision-making power, forcing them to be economically dependent on other household's members and their needs being overlooked (Amugsi *et al.*, 2016). Moreover, it has been evidenced that in many households, women often eat last and least, consuming leftovers and less nutritious foods and follow food restrictions, further decreasing their dietary diversity (Harris-Fry *et al.*, 2018). Furthermore, the inheritance of property and lands

remains patrilineal, passed from father to son. The resource-dependence on men makes marriage, in some regions, considered as the most socially accepted path for women.

In both rural and urban Nepal, women bear the double burden of sustaining long hours of work in farms and factories, contributing to the formal economy, and yet managing household chores, hence restricting their time and energy allocated for their health and nutrition. However, their contribution remains invisible due to traditional gender-norms (World Food Programme, 2022). In the Western Terai plains, like Bardiya District, women face further restrictions, exacerbated by the socio-economic conditions of the area. They have, to a greater extent, limited mobility, financial independency, marriage choice, access to lands and markets, education compared to the Hill region. Studies have shown that education status, family size and community affiliation, have a significant impact on food security (Radhika *et al.*, 2018). Censuses of population in 1991 and 2001 indicated a gender-selective abortion because of the lower status of women (Nanda *et al.*, 2012). This preference for male children, associated with women's low social status, further affects their access to nutrition and healthcare. Their economic dependence and mobility restrictions reduces their access to health facilities and markets. The higher prevalence of early marriages in the Terai plains, resulting in early pregnancies contributes to poor nutrition and health for both the mother and the child (Asian Development Bank, 1999).

1.5 Bardiya District

As it has been observed, the Terai population, particularly women, face exacerbated challenges due to their marginalized position and lack of governmental support, which have direct impacts on their nutritional status. Availability, affordability, accessibility and desirability of foods are also key factors that are associated with eating habits. To provide a comprehensive understanding a contextual overview exploring the physical, economic, and associated nutritional constraints specific to the Bardiya District is provided.

1.5.1 Physical Characteristics

Located higher from Uttar Pradesh, India, in the Terai plains of Nepal, the Bardiya District occupies 2 025 square kilometres. This region has low-lying fertile plains, which are highly practical for agriculture, and Chure Hills, bringing a diverse topographical landscape and permitting the development of several crops and livestock (Namaste Sindhupalchowk, n.d.). Bardiya experiences two major weather systems: the “summer monsoon circulation”, from June to September, and “westerly circulation”, from November to May (Karki *et al.*, 2015). The mean annual temperature varies between 24 and 28 degrees Celsius, with an annual precipitation between 1000 and 1800 mm. Bardiya, according to the Koppen-Geiger Climate Classification Map, got reclassified with a Tropical Savannah climate, due to its low altitude (below 400 meters). This warm and humid climate is essential for the

cultivation of paddy, which represents more than 50% of the Nepal's cereal production (Karki *et al.*, 2015).

With an essential role in agricultural production, Bardiya's plains are mainly cultivates major cereal crops such as paddy, wheat, millet, barley and buckwheat, covering a total area of 78 415 hectares for the year 2021-2022. Pulses, spices and summer fruits (Mango, Papaya...) mostly grow in the Chure Hills. Livestock farming is also important for the district, gathering cattle, buffaloes, ducks, fowls, pigs and sheep (Ministry of Agriculture and Livestock Department of Nepal, 2023). That same year, approximately 8 300 hectares were allocated, very few compared to cereal production, to the cultivation of fresh vegetables. However, the district lacks significant production of winter fruits (Ministry of Agriculture and Livestock Department of Nepal, 2023).

Although these statistics suggest a production of varied crops permitting a likely available nutritious diet from both the flora and the fauna (Liu *et al.*, 2023), this production does not necessarily reflect the economic realities of the studied area. It does not ensure the accessibility, affordability, and desirability of these products for the nearly half millions of people living in the district. In fact, despite the Terai region being one of the country's most productive in agriculture, it also presents the highest undernutrition rates (Global Hunger Index, 2020). This difference shows that food availability is not the only factor influencing food consumption patterns.

1.5.2 Economic Characteristics

Nepal is a country that faces economic challenges and poor economic growth, due to its development level and isolation. The local food supply is not able to meet the needs of the population, making food security fragile and closely associated with issues of poverty, access and affordability of foods (Liu *et al.*, 2023). Ensuring a balance between food supply and demand remains essential for permitting access and affordability of staple products. In fact, today, the Terai plains, including Bardiya, is the only area producing surplus crops, compared to the food demand (Adhikari *et al.*, 2021), as presented in the Figure 2 beneath. However, this surplus does not balance out the production deficiencies in other regions of Nepal, presented as critical balance or overload in this figure.

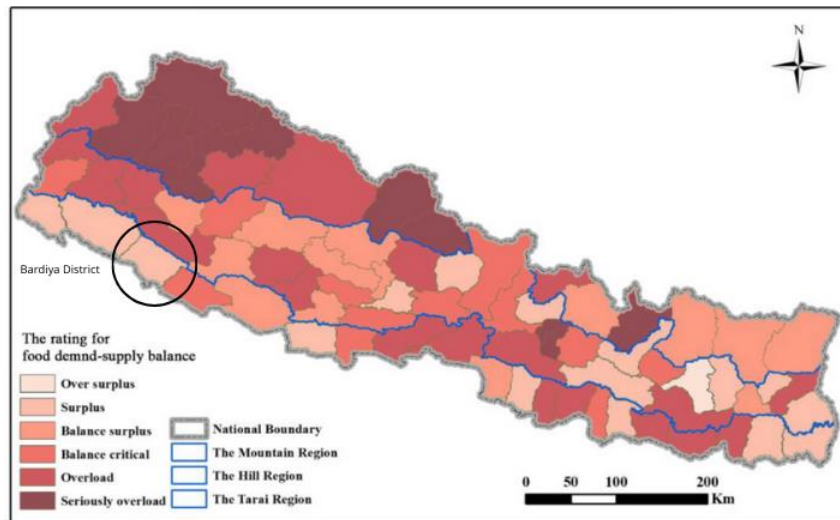


Figure 2 Deficiencies and Surplus in Production according to the Ecological Region (Liu *et al.*, 2023)

These production deficiencies explain Nepal's reliance on food imports increase, with a 65% rise in agricultural imports between 2015/2016 and 2019/2020 (Adhikari *et al.*, 2021). Research explains that these import trends are driven by a combination of socio-economic and cultural factors, political instability, inefficient food production and imports, a free-market economy, among other reasons (Adhikari *et al.*, 2021). Nepal is not self-sufficient in most commodities, like cereals, vegetables, potatoes, milk, sugar, meat with the heavier import-dependencies noted for fruits, oils, fish, and pulses (Pokhrel, 2020). Nepal's dependence on international and Indian trade makes it vulnerable to the global food prices, which are influenced by trade policies, export taxes, import subsidies or restrictions imposed by exporters or importers (Giordani *et al.*, 2014).

Generally, it is assumed that imported food is more expensive than locally produced commodities because of transportation costs. However, the high costs of imported agricultural inputs can also increase locally produced foods and seasonal variations in food production can affect availability and prices, during off-seasons, thus, locally produced foods may be more expensive than imported goods (Oxfam, 2011). Bardiya district, due to its position, is particularly influenced by India's economic and market dynamics, consequently impacting local food prices, accessibility, affordability and availability. International trade, associated with the absence of effective price stabilization measures, also makes Bardiya more vulnerable to variation of prices. Reasonably, Bardiya benefits from lower Indian food prices due to reduced transportation costs compared to more distant regions of Nepal (Adhikari *et al.*, 2021).

While the Terai plains, including Bardiya, produce more staples than many Nepali regions, which reduces transportation needs and keeps locally produced-foods prices lower, this ecological region does not produce several foods, such as winter products. As a result, it is to be expected that

these foods will be more expensive in the plains than in the producing regions. Overall, because of the surplus production in Terai area and the closeness to India, it seems that locally produced and Indian foods are easily available. Nevertheless, hills or mountains-production may be access-limited due to challenges in the distribution system, including difficult road infrastructure all over Nepal. Therefore, the affordability and availability of these products in Bardiya may be restrained (Adhikari *et al.*, 2021).

For instance, in April 2024, products affordability shifted, as foods and beverages prices increased differently between regions, which the highest inflation was observed in the Terai region (5.6%) and lowest in the mountains (3.2%). In addition, the high density of population in the plains and its reliance on Indian products aggravates prices fluctuations; if Indian there is an increased demand for products also sold in the Terai, nepali prices may increase (Palikhe *et al.*, 2024).

These economic and agricultural characteristics directly affects affordability and availability of products, impacting food security and nutrition across Nepal, particularly in the Terai region. Nevertheless, other underlying factors, such as cultural and political influences, affect dietary habits and food availability.

1.5.3 Nutritional Status, Dietary Patterns, and Food Security Challenges

To address food security, around 30 policies, acts and regulations were implemented in Nepal, from which eleven underlined nutrition interventions, such as supplementation, improved feeding practices and addressing nutrient deficiencies diseases. While the government tries to improve food security, these initiatives neglect other types of malnutrition related to overnutrition and other diet-related noncommunicable disease (Adhikari *et al.*, 2023). Also, the needs of vulnerable populations are often too significant, the assistance provided not enough, data monitoring and evaluation challenging, making it difficult to assess the efficiency of these interventions. Furthermore, these programs may lack local specificity and have difficulties to consider the cultural limitations of certain populations (Adhikari N. *et al.*, 2023).

However, aside of the governmental policies, household eating habits play a critical role in influencing nutritional status in Nepal. In fact, the 2016 Nepal Demographic Health Survey (NDHS) showed that the Nepalese diet is traditionally monotonous and cereal-based (Shrestha *et al.*, 2021). The insufficiency of vegetables, fruits and animal-sourced food intakes increases the risk of malnourishment. Studies show that there is little difference between rural and urban diets (Liu *et al.*, 2023) and, as per the Indian Council of Medical Research (ICMR, 1985) and WHO (1986) recommendations, cereals consumption per capita must be reduced while other food groups consumption increased (Pokhrel, 2020). Cereals could be replaced with other carbohydrates (tubers, wheat or maize) to improve micronutrient adequacy (Pokhrel, 2020). Vegetables, though included in the diet, are consumed in small portions and seen as flavorings rather than for their essential role in

human health. Moreover, cultural beliefs and traditions significantly influence food consumption patterns, categorizing some foods which restrain the consumption of available and affordable foods and affecting their desirability (Adhikari, 2010).

Because of these eating determinants, significant micronutrient deficiencies have been observed among the Terai population, notably in vitamin A, iron, riboflavin and selenium, with intakes of below 50% of the recommended intakes. Their diet consisted in important amounts of rice, with small portions of side dishes such as curry or dal (Parajuli *et al.*, 2012). Some different patterns of food consumption have also been evidenced for pregnant and lactating in Nepal. In the mid-western part of Nepal, Bardiya district included, tubers and roots showed to be less consumed, while cereals just the same, as in other parts of Nepal. Pulses and legumes were also less consumed. Milk consumption was more prevalent among women with higher educational levels. Differences in mother's diets were found different according to their place of living, education and wealth (Bhandari *et al.*, 2016).

1.6 The Interaction of Determinants Influencing Dietary Choices

This previous section demonstrated that a multitude of interconnected determinants influence the nutritional status of breastfeeding and lactating Mukta-Kamaiya – factors such as community history, household dynamics, agricultural challenges, cultural beliefs and gender roles. Their impact is evident, referred to in Appendix B, in food affordability (through market prices and fluctuations, wealth and employment), availability (dependent on local and national agricultural productivity, climate and imports), and accessibility (shaped by infrastructures and household dynamics). Finally, food desirability is mainly influenced by cultural norms, food preferences and taboos, media and health campaign. A majority of eating determinants identified are presented in Figure 3 which highlights the difficulty to address one aspect without considering others, making cross-disciplinary improvements necessary for achieving sustainable impacts. These components play a crucial role in local nutrition but leave the most vulnerable groups in greater insecurity.

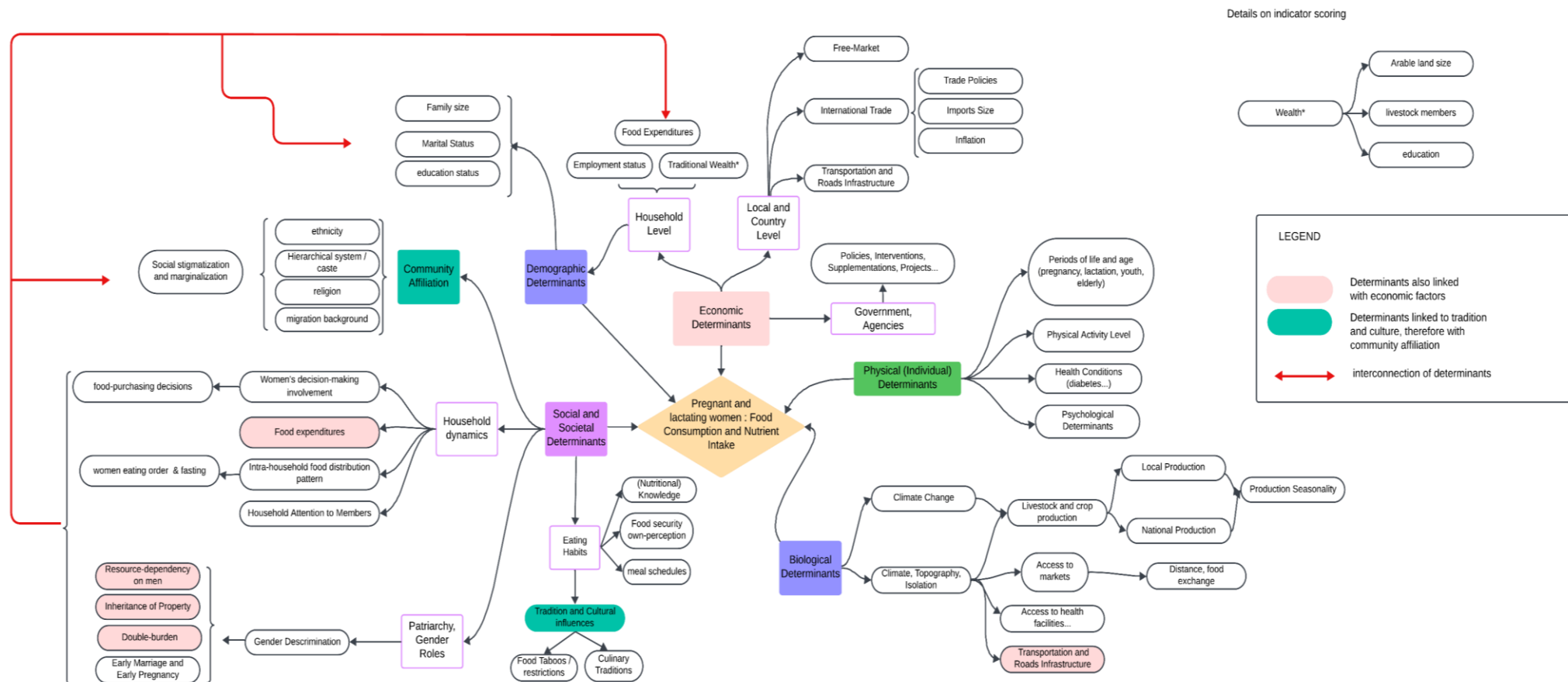


Figure 3 Interconnected Determinants Influencing Food Consumption and Nutritional Intake Among Pregnant and Lactating Women in Bardiya District, Nepal (Emma Opitz. 2024)

II. Materials and Methods

To assess whether some of these challenges persist today, this study sought to provide a comprehensive overview of various determinants. It will subsequently examine whether nutritional difficulties continue to disproportionately affect the studied vulnerable group, with a particular emphasis on the role of household indicators.

2.1 Study Framework

This study was shaped to assess the nutritional status and eating determinants of the freed-Kamaiya community and more specifically, pregnant and breastfeeding women. It was designed on a comparative analysis between Mukta-Kamaiya pregnant and lactating women and those of other communities in the Bardiya District, Western Terai of Nepal and more especially in the Mainapokhar Village, which can be identified on the Figure 4 beneath.

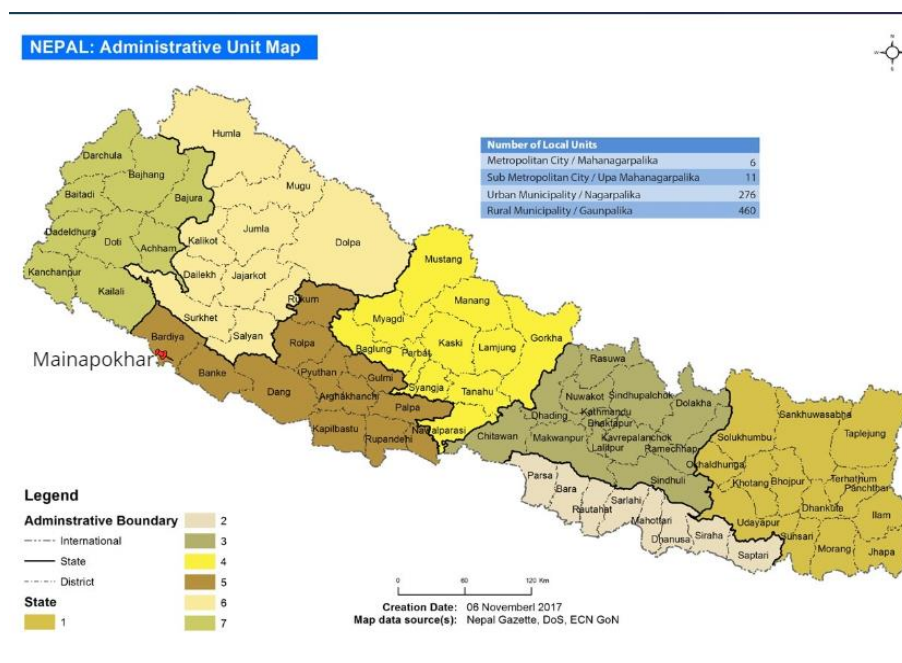


Figure 4 Map of Nepal's Administrative Structure and Mainapokhar Localisation (United Nations Nepal, 2018)

Having the juxtaposition of contexts between the two populations is crucial to understand the potential disparities and thus bring up the hypothesis that the Kamaiya system has, still now, impacts on their nutritional status. Therefore, this research was conducted to answer to a set of questions that highlighted differences of nutrient adequacy, eating determinants and food consumption patterns, through the implementation of a 24-hour dietary recall⁴ and an individual, household and eating habits survey.

⁴ A survey based on recalling all foods and beverages eaten the past 24 hours by the participant

The overall study lasted 6 months, beginning with a month allocated to identifying the study research theme, drafting the study's questions, and establishing the methodology for data collection. The data collection was scheduled for early May due to logistic considerations and avoid the rainy season. Following this period, the subsequent two months were allocated to data processing and translation, followed by a period of data analysis and literature review. The final phase was dedicated to writing the comprehensive report and provide suggestions for the FAO Nepal project.

2.2 Study Type

This research is best characterized as a retrospective descriptive study aimed at describing the characteristics of populations and situations over a certain period. Given its comparative nature between two populations (Mukta-Kamaiya and non-Mukta-Kamaiya), it can also be classified as a comparative cross-sectional study. Additionally, it qualifies as a mixed-methods study, as it incorporates both qualitative and quantitative data collected from the field.

2.3 Data Collection Period

The overall study lasted 6 months with a one-week data collection period, from the 29th of April until the 4th of May 2024 and an average of 12 interviews per day. Moreover, since it is important for 24-hour dietary recall to ensure that the recorded eating day is representative of daily consumption, the day chosen for the recall was not a festival nor anything outside of habits, as confirmed from the participants. All interviews started with the qualitative data collection to understand the context of the participants, ending with the dietary recall.

2.4 Enumerators

For this data collection, a team of five enumerators participated. Two were from the World Food Forum Nepal, and one was from the NACCFL, facilitating better communication and understanding with the producer's organization (PO) of Mainapokhar, that permitted the census of the pregnant and breastfeeding women from the municipality, and that coordinated the interview schedules. The remaining two enumerators were FAO interns, including the author. The five enumerators were divided into three groups, each responsible for conducting four interviews per day. An interpreter from the PO accompanied each group to provide support in the Tharu language and enhance a trusting atmosphere. The interviews were primarily conducted in Nepali, with some inputs in Tharu.

2.5 Sampling Methodology for Pregnant and Lactating Women

The primary objective was to represent through the sample pregnant and lactating Mukta-Kamaiya women from the Bardiya District. However, due to logistical constraints and concerns about representativity, the study was geographically limited to the Mainapokhar Village, which was assumed representative of Bardiya District, given the similar living conditions and community composition.

Initially, the sampling method aimed to use the district's ethnicity census to determine the number of Mukta-Kamaiya participants needed for adequate representation, with an equal number of participants from other communities. Nevertheless, the available demographic data was limited, providing only global numbers of the expected pregnancies and lactating women in the whole municipality and an estimated number of Mukta-Kamaiya households in the Mainapokhar's associated wards (50-60 households in wards 6 and 7). The lack of information on Mukta-Kamaiya pregnant or lactating women made it very difficult to determine the sample size, which should have been similar for the non-Mukta-Kamaiya group to ensure a valid comparative analysis (Excel census provided by NACCFL, Producers Organization, April 2024).

Therefore, the sampling approach was adjusted based on what was feasible. Given the short-term nature of the study and its execution by a single researcher, it was crucial to establish realistic goals. After consulting with the internship supervisor, the AgroParisTech supervisor, and a statistics professor, it was agreed that a population of 30 would be a reasonable starting point. This choice was supported by the Central Limit Theorem (CLT), which considers that for a sample size equal or greater than 30, the distribution is often normal, allowing parametric tests to be used (Brussolo, 2018). Therefore, the study aimed to have a total of 60 women—30 Mukta-Kamaiya and 30 women from general communities of the area, with 15 pregnant and 15 breastfeeding women in each group, as they were the target of the NACCFL project. However, it was determined that pregnant women who were also breastfeeding would not be included, as their nutritional requirements are not specified in FAO/WHO guidelines.

2.6 Study Variables

To address the research question and hypothesis, variables were selected and categorized into nutritional inputs and eating determinants. The latter includes socio-economic and demographic factors, household dynamics, agriculture and livestock diversity, as well as eating dynamics. Not all determinants represented in Figure 3 could be calculated and scored, due to the study's time constraints and methodology. Therefore, only a few were chosen. An overview of these theoretical variables, guided by Becquey's (2016) research, is provided in Appendix C.

2.7 Data Collection Methods and Tools

To address the objectives of this study and variables, the data collection was divided into two parts: the first part gathered qualitative, socio-economic demographic information and eating habits insights while the second part was dedicated to a 24-hour dietary recall, a quantitative dietary survey conducted.

No tool nor methodology was implemented for the first part of the interview, which also served to instore a trusting atmosphere and to explain the objectives of this study. The interview was following a directive methodology, enabling a comprehensive data comparison. However, the 24-hour dietary recall required a particular methodology and a variety of tools. Accurate food intake data collection can be challenging in the field; thus, it was crucial to have a Food List of the region, a Portion-Sized Food Atlas and a Food Composition Table with all nutritional composition per dish. These crucial tools also supported the survey and helped the participants to remember all the products eaten. All three essential resources were requested through ResearchGate (Harris-Fry *et al.*, 2015-2016).

Finally, the participant's Body Mass Index was calculated with a measuring tape and a body weight scale, to verify that no women were underweight during these periods, and to identify if the nutrient intakes aligned with their body needs.

The methodology of the dietary recall followed a strict, and accepted methodology, divided into 4 main steps. Firstly, the quick list of the food consumed in the past days had to be written down. The second stage was about ensuring that no food was missing, by asking particular questions. Afterwards, the time and place were asked and then the final opportunity to recall all foods consumed took place. When all was confirmed, the food or dish code and the portion code were collected. In case the item was not recorded in the Food List, the recipe was written, including each ingredient, raw quantities, water additions, condiments, and the cooking procedure (Chinese University of Hong Kong, 2005; Becquey, 2016).

2.8 Data Processing and Translation Methods

Later, the collected qualitative and quantitative data had to be processed into devices and translated into usable data.

The first type of data was entered into Excel using Kobo Toolbox Survey, and any missing information was addressed as needed. No additional processing was required for the qualitative data.

For the dietary quantitative data, an individual Excel file was created for each participant to record their dietary recall. Most of the data translation involved converting the food portions into total daily intake of macro and micronutrients for each participant.

Therefore, for this important step, all foods eaten with their precise amounts in grams were input in the excel sheet. Most of the foods were found in the Food Composition Table of the Terai Region (Harris-Fry *et al.*, 2015-2016) with their nutrient composition per 100g, allowing a direct calculation of the nutrient intake per portion eaten per food. However, some foods were not documented in this table, obliging a calculation of the nutrients present in the home-made recipe. In

this case, recipe nutrient calculation was based on the raw ingredients and quantities used per dish given by the participant. The Ingredient Method was applied, to convert raw quantities into cooked quantities and to take into consideration nutrients degradation according to the cooking method (pan fried, boiled, deep fried...). In fact, as the interviewed women had consumed the cooked portion of their recipe, it was essential to consider the nutrient composition and ingredient-weight change that occur during cooking processes for a more accurate assessment of nutrient intakes (EuroFIR, 2014). The related calculations are detailed in Appendix D.

Therefore, the calculation of overall nutrient intake per food item and per day for each participant was based on either direct use of the food composition table, when possible, or on the participant-provided recipe. Any precision errors coming from these factors were accepted to permit the subsequent phases of data analysis.

2.9 Evaluation of Indicators and their Measurement

To have a comprehensive vision of the food intake, it was useful to support statistical data analysis with indicators that could permit a better interpretation and confrontation of the realities. Different indicators could be measured at a **personal or household level** and assessed through this study.

2.9.1 Evaluation of Socio-Economic Indicators

First of all, indicators were measured from the variables of the first part of the interview and brought a comprehensive scoring of some socio-economic and demographic variables.

To begin with, **the Wealth Indicator** is an indicator that was calculated based on traditional wealth as it was fundamental to provide an understanding of household wealth. In truth, wealth has an important influence on access to food and therefore nutrient's adequacy of each family member, and thus must be considered as a food habit behavior determinant. Generally, modern and traditional wealth are measured differently and are chosen according to the targeted population's living conditions. In rural areas, it is relevant to assess traditional wealth which depends on the parameters taken into consideration that provide insights on household belongings and value (Garenne, 2014). In this study, it therefore seemed more appropriate to evaluate traditional wealth by identifying crop productions and livestock systems handled by the household, as they not only serve for household consumption and selling but also to define the household's social status within. Income levels were undoubtedly considered for this evaluation. Another interesting wealth criterion is household workforce, defined by its member numbers, as this represents the capacity of a household to provide the necessary needs for each member to live (Garenne, 2014). Thus, arable land size per capita, herds

per capita and income per capita were calculated, upon which a household wealth score was given, with higher values indicating better wealth scores.

Moreover, as discussed in the first section of this report, the **decision-making power score** has several impacts on women's access to food and conditions of living. To facilitate a consistent comparison between households, a decision-making power score was developed, reflecting the participants' influence over food-related decisions. This indicator was based on whether the participant was the household head, the person purchasing foods and the main cook. A higher score suggested a heavier decision-making authority regarding food, as the scoring methodology details in Appendix E.

Furthermore, to assess the woman's position within the eating hierarchy of the household, a **food dynamics score** was developed (explained in Appendix F). It represented the order in which she ate usually (which impacts the quantity and quality of the food consumed), as well as the monthly food expenditure per person in the household. A lower score suggested preferable better food dynamics, inducing higher monthly food expenditures per person and favorable positions in the hierarchical eating order for the participants.

Finally, the **Food Insecurity Experience Scale (FIES)**, based on 9 questions of food insecurity levels, is a global tool highlighting the challenges faced by the household, beyond just assessing their nutritional intakes and diversification of diet. Each question represented an assumed severity level of food insecurity and based on the answers (experienced or not) a score was given (FAO, 2018). Higher scores indicated a great severity of food insecurity, as presented in the methodology in Appendix G.

2.9.2 Evaluation of Nutritional Indicators

After all final dishes composition and weight were assessed, an analysis was then made to estimate the adequacy of the populations' intakes compared to FAO/WHO guidelines. From the 24-hour recall data, Nutrient Adequacy Ratios, the Global Nutrient Adequacy Ratio, MDD-W indicators were calculated for both populations and eating habits were identified and served as the main variables for assessing their nutritional dynamics.

First, the **Nutrient Adequacy Ratio (NAR)** indicates the adequacy of the participants intake compared to the nutrient intake requirements. As it is not possible to directly compare intakes between the participants due to distinct needs, it was convenient to use a Nutrient Adequacy Ratio that could provide a standardized way to compare nutrient adequacy. If the result is lower than 1, the recommended intake was not met, while if they are bigger than 1, the requirements were met.

The nutrients which were both provided by FAO/WHO requirements and by the Food Composition Table, and for which NARs were calculated, included the following: energy (kcal), fat (g), protein (g), fibre (g), calcium (g), iron (mg), magnesium (mg), sodium (mg), zinc (mg), copper (mg), selenium (µg), vitamin C (mg), thiamine (mg), riboflavin (mg), niacin (mg), pantothenic acid (mg), vitamin B6 (mg), folate total (µg), vitamin B12 (µg), vitamin A RAE, vitamin E (mg), vitamin D (µg), vitamin K (µg). The specific nutrient requirements varied among participants depending on factors such as age, lactation and breastfeeding status, weight, and height.

Secondly, the **Mean Adequacy Ratio (MAR)** was calculated based on the NAR, to provide unique value representing the quality of the diet. The MAR score varies between 0 and 100%, or 1, the latter indicating that the requirements for all nutrients were met.

Moreover, the **Minimum Dietary Diversity for Women (MDD-W)** was measured, providing a comprehension on the diversity of the daily diets of women, based on the consumption of 10 food groups, which consumption of each food group is positively correlated to micro-nutrient adequacy. In general, the consumption of 5 or more food groups is acceptable and positively associated with high nutrient intake (FAO & FHI, 2016). A score between 1 and 2 indicates a low dietary diversity, 3 to 4 a moderate diversity, 5 to 6 is considered acceptable and 7 to 10 high or very high dietary diversity. Additionally, analysing the MDD-W score brings insights regarding which groups are consumed or missing, identifying potential eating habits and nutritional gaps within a population.

Finally, a **Rice Consumption Indicator** was developed, given the significant role of rice in the Nepalese diet. This indicator aimed to assess the percentage of total energy derived entirely from rice intake, providing insights into dietary trends.

For these four indicators, further scoring methodology is provided in Appendix H.

2.10 Quantitative and Qualitative Data Analysis

These variables and indicators were analysed to provide a comprehensive understanding of the dynamics between the two specific populations studied. Both quantitative and qualitative approaches were employed using SAS On Demand software. Initially, descriptive statistics were used to explore the demographic characteristics of the participants, contributing to a better perspective of the targeted populations and their living conditions.

The quantitative data, provided by the 24-hour dietary recall, allowed the calculation of NAR, MAR and MDD-W scores. Inferential statistics, such as T-tests and clustering procedures, were the main methods to compare the nutrient adequacy and dietary diversity between the two populations. More especially, a One-Sample T-Test was conducted to determine if the mean nutrient intake for the whole population was significantly different from the FAO/WHO recommended dietary allowances.

Clustering analysis was used to identify any differences in global habits, both in nutrient intakes and in food group consumption, between the populations. However, before implementing the clustering procedures, which involved determining the optimal number of clusters based on Cubic Clustering Criterion, Pseudo F statistic and Pseudo T-Squared criteria, and processing a k-means clustering method, outliers were excluded from the analysis to prevent distorted results in the clustering representation.

Moreover, the qualitative data, collected during the first part of the interviews, were analysed to find any correlations between socio-demographic and economic variables, such as wealth, education, and food insecurity, with dietary outcomes. Any significant correlation between these determinant variables were excluded to avoid confusion in the results. The qualitative data brought context to the quantitative results, offering insights on the factors influencing dietary choices.

III. Overall Results

3.1 Socio-Demographic Characteristics of Households and Participants

To begin with, the gathered data helped the understanding of the participants' characteristics, which descriptive statistic is provided in Table 1.

Among the 61 women interviewed, 30 were from the Mukta-Kamaiya community, all Tharu ethnicity. The remaining 31 women were from various ethnic backgrounds within the non-labourer system, standing for the diversity of the Bardiya District population. Most women were aged 20 to 35 years old; one participant was not yet an adult, and 11% of the total population were underweight, based on calculation for non-pregnant women. Pregnant and lactating women in the first trimester were less represented (17%) compared to those in the second (38%) and third trimesters (45%). Most of the women completed their education during middle school while only a small percentage (3%) never attended to school. Out of 61, 3 women reported to be employed, though unrecognized by the state and self-employment means.

Table 1 Descriptive statistics of the participants' characteristics

Categories	Modalities	Count (n) Out of 61	Percentage (%)
Ethnicity	Tharu (Janajati group)	41	66
	Brahmin ("upper caste")	10	16
	Chamar (Tarai/Madhesi Dalit)	1	2
	Chhetri ("upper caste")	1	2
	Dalit (marginalized group)	5	9
	Janajati (unspecified)	2	3
	Yadav ("Tarai/Madhesi Other Castes")	1	2

Age	<18	1	2
	18-20	5	9
	20-25	27	44
	25-35	27	44
	>35	1	2
Underweight	BMI<18,5	7	11
Pregnant	First Trimester	3	5
	Second Trimester	12	20
	Third Trimester	15	25
Lactating	0 to 3 months	7	12
	3 to 6 months	11	18
	> 6 months	12	20
Education	Never attended	2	3
	Elementary school	4	6
	Middle school	39	64
	High school and more	16	27
Employed	Self-employment	3	5

Additionally, statistics of the socio-demographic variables for Mukta-Kamaiya women, Non-Mukta-Kamaiya women, and the entire population are shown in Appendix I. Noticeable differences between the two groups included lower wealth scores for Mukta-Kamaiya women despite a higher minimum income compared to Non-Mukta-Kamaiya. However, the latter group earned the highest income, with an added 80 000 Nepalese rupee (NPR) compared to Mukta-Kamaiya's highest income. Similarly, Mukta-Kamaiya households owned less land, with a maximum of 15 khatta compared to 80 khatta for the other households. There were no significant differences in the number of crops produced, decision power, food dynamics scores, or household size. Nevertheless, Mukta-Kamaiya women had longer land ownership and owned more animals on average.

Finally, a review of the crop production and livestock management within the households, as displayed in Appendix J, has revealed that 28 Mukta-Kamaiya and 27 non-Mukta-Kamaiya kept animals and only 2 Mukta-Kamaiya households did not engage in any crop production.

Significant differences in agricultural practices between the groups were identified, with Mukta-Kamaiya households preferring mustard, vegetables, and potatoes crops, while non-Mukta-

Kamaiya households primarily cultivating wheat, maize, and legumes. The latter were more likely to sell their produce (61%) compared to Mukta-Kamaiya households (40%), who tended to consume their produce due to less-market oriented crops and smaller landholdings. Notably, rice was grown by all landowners, highlighting its essential role in the diet.

Regarding livestock, non-Mukta-Kamaiya households owned significantly more cattle (33% vs. 11% for MK) and buffaloes (48% vs. 36% for MK), which could suggest greater wealth, land availability, and market access, especially for dairy products. Moreover, poultry ownership varied: Mukta-Kamaiya households had more laying hens and ducks, while non-Mukta-Kamaiya households had a more diversified poultry approach with higher proportions of fowls. Non-Mukta-Kamaiya households also used livestock for both sale and consumption (66% vs. 42% for MK), while Mukta-Kamaiya households focused on consumption (50% vs. 33% for non-MK), suggesting a subsistence strategy.

3.2 Analysis of Participants' Nutrient Intakes

Shifting from the participants' demographic characteristics, the exploration of the nutrient intakes of the participants was undertaken.

The first hypothesis of the study reflected on whether there is a disparity in nutrient adequacy dynamics between the two communities, with a higher prevalence of deficiencies observed in the Mukta-Kamaiya Community. Throughout this section, sub-questions were explored and answered:

- Are my target groups meeting the recommended intake for essential nutrients?
- Have any deficiencies been identified, and if so, which specific nutrients are lacking?
- Are there discrepancies in nutrient adequacy between the compared groups?

3.2.1 Nutrient Adequacy Ratio Trends within the Overall Population

Firstly, to examine if the average nutrient intake of the entire sampled population matches the FAO/WHO recommended dietary allowances (RDA), inferential statistics were implemented by a One-Sample T-Test with a 95% confidence level. For this, the variable used was the Nutrient Adequacy Ratio and compared to the perfect intake according to the RDA (100%) and two hypotheses were tested:

H0: The sample mean of the nutrient intake adequacy ratio is equal to the RDA ratio ($\mu = \mu_0$, where $\mu_0 = 1$, representing an intake perfectly equal to the RDA).

H1: The sample mean in nutrient intake adequacy ratio is not equal to the RDA ratio.

The T-Test results permitted the acceptance of H1 and showed that for most nutrients, except for vitamins C, B3, and B5, there is a significant difference ($Pr > |t| < 0,05$) between the average intake and the RDA for the overall population. This means that the intake can be significantly higher or lower than the RDA. Appendix K provides more details on these intake dynamics, with excessive intakes seen for fats, proteins, magnesium, sodium, selenium and vitamin K meanwhile all the remaining

nutrients showed perfect intake (e.g. fibres) or deficiencies. Nevertheless, trends in sodium and selenium intake are concerning due to their exceptionally high levels. These trends represent the nutrient intake within the overall sampled population. However, it is important to study any possible differences between the two specific populations: Mukta-Kamaiya and Non-Mukta-Kamaiya.

3.2.2 Nutrient Adequacy Ratio Comparison between MK and non-MK

A T-Test was conducted to compare nutrient intake adequacy ratios between two populations, with Mukta-Kamaiya affiliation (1 = yes, 2 = no) as the explanatory variable. The hypotheses were the following:

H0: There are no significant differences in the nutrient adequacy ratios between the two groups.

H1: There are significant differences in the nutrient adequacy ratios between the two groups.

This step highlighted significant differences for the intakes of proteins, fibers, calcium, iron, magnesium, copper, selenium, vitamin B2, vitamin B3 and vitamin B12. The nutrient adequacy ratio was shown to be higher for every of these nutrients for Non-Mukta-Kamaiyas, as presented in Figure 5. However, from these differences, Mukta-Kamaiya women showed underconsumption of fibres, calcium, iron, copper, vitamins B2, B3 and B12 but an adequate consumption of proteins, magnesium and selenium. Non-Mukta-Kama had still an underconsumption of calcium and iron.

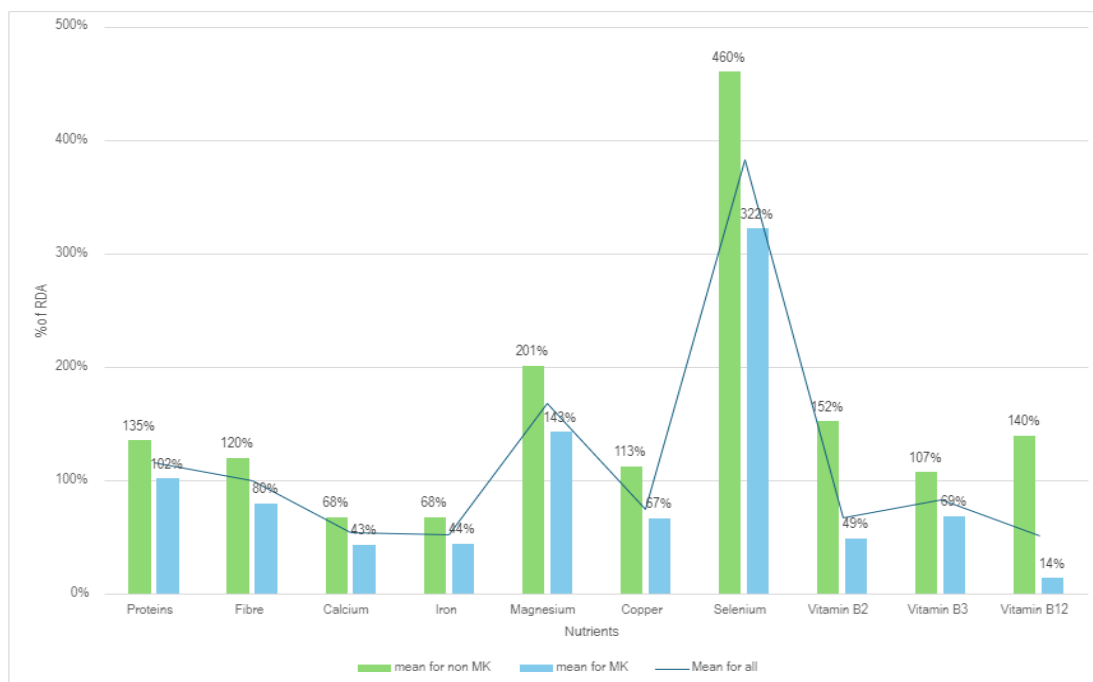


Figure 5 Histogram of Nutrient Intake Ratios to 100% RDA Showing Significant Differences between Mukta-Kamaiya and Non-Mukta-Kamaiya Populations

Finally, considering all nutrients, not only those showing significant differences, while Non-Mukta-Kamaiya women showed an over-intake of copper, Vitamin B1, B2, B3, B5 and B12, Mukta-Kamaiya women showed under-intakes bringing forward the higher deficiencies experienced by MK.

3.2.3 Nutrient Adequacy Ratio Classification

For identifying groups of individuals with similar nutrient intake patterns and to detect deficiencies or surplus within the entire population, it seemed beneficial to classify the participants according to their nutrient intake adequacy ratios. This procedure could provide interesting insights to tailor more targeted nutritional interventions.

a. Outlier Identification

A major step to consider implementing was the identification of outliers according to the variables met. Indeed, extreme values that are far from the main cloud of values should be named and treated, as they may result from mistakes from the participant response error (Kwak & Kim, 2017). They might distort trends and lead to incorrect classifications.

In this first step, the outliers were identified using nutrient adequacy ratios by calculating the Euclidean distance of each data point from the centroid of selected Principal Components Analysis (PCA) variables on SAS on Demand Software. Outliers were identified as the data points with distance exceeded the mean distance plus two standard deviations. Three outliers were found: two non-Mukta-Kamaiya and one Mukta-Kamaiya observations were removed for the first part of the analysis, resulting in a sample-size of 29 Mukta-Kamaiya women and 29 non-Mukta-Kamaiya women.

b. Nutrient Adequacy Ratio Classification

To begin with, the number of clusters to create was decided by using the clustering procedure on SAS. After the analysis of the Cubic Clustering Criterion (CCC), Pseudo F Statistic, and Pseudo T-Squared values, four clusters seemed to be the favourable choice. Therefore, based on these criteria, four clusters were chosen for the data segmentation. Subsequently, the k-means procedure distributed each participant to each cluster, which aspects are shown in the Table 2.

Table 2 Clusters based on Nutrient Adequacy Ratios Patterns

Clusters	Size	Nutrient Adequacy Ratios Patterns	Proportion of MK	Proportion of non-MK
1	5	Higher Fat Intake Adequacy, Higher Fiber Intake Adequacy, Higher Vitamin C Intake Adequacy	0	5
2	37	Lower Energy Intake Adequacy, Lower Iron Intake Adequacy, Lower Magnesium Intake Adequacy, Lower Zinc Intake Adequacy, Lower Copper Intake Adequacy	24	13
3	1	Higher Iron Intake Adequacy, Higher Copper Intake Adequacy	0	1
4	14	Higher Calcium Intake	5	9

The differences in nutrient intakes between the clusters are salient. The largest cluster, covering 66% of the population and predominantly Mukta-Kamaiya, is characterized by low intakes in energy, iron, magnesium, zinc, and copper. In fact, a Chi-square test showed a tendency for Mukta-Kamaiya women to be more prevalent in this cluster compared to Non-Mukta-Kamaiya, with a p-value of 0,0705. However, as this statistic test is moderately higher than 0,05, the null hypothesis stipulating that there is no significant difference in the proportion of MK and Non-MK in Cluster 2 cannot be rejected.

Additionally, no significant differences in socio-demographic variables were observed between the clusters, except for the wealth score. In fact, the ANOVA test, performed with the Wealth scores according to the Cluster Affiliation, showed a F-test p-value that rejected the null hypothesis, suggesting that there is a statistically significant difference in the wealth score between clusters.

To find which clusters are significantly different between them, a Tukey post-hoc test was implemented. The results showed a difference in the wealth scores mean between clusters 1 and 4, and clusters 1 and 2. Significantly lower mean Wealth Scores were found for cluster 2 and cluster 4 (10,7 and 11 respectively).

3.2.4 Mean Adequacy Ratio Trends and Comparison

Mean Adequacy Ratios were calculated for every woman. With the Satterthwaite Method, the T-Test showed a significant difference of the means ($Pr>t = 0,0085$) between the Mukta-Kamaiya and non-Mukta-Kamaiya (with Mean Adequacy Ratios Scores of 59% and 70% respectively). The results of this initial analysis confirm the differences in the overall nutrient intakes between the two populations. Despite highlighting the overall poor adequacy of the FAO's recommended dietary allowances among the women assessed, it has been significantly showed that Mukta-Kamaiya pregnant and lactating women have a less adequate diet compared to women from other communities.

3.3 Analysis of Participants' Dietary Diversity

Following the nutrient intake analysis, this next part of the analysis explores if Freed-Kamaiya women exhibit a lower MDD-W score compared to women from other communities. The three following sub-questions should be answered:

- Are there disparities in MDDW Scores between the two groups? What are the disparities?
- Are there disparities in consumption patterns between the two groups: Are there Classification of Diets according to the food groups in the total sampled population?
- What specific foods or food groups does my target groups consume?

3.3.1 MDD-W Score Trends

Firstly, the Figure 6 was elaborated to illustrate the distribution of the Minimum Dietary Diversity for Women and highlights variations in dietary intake. With an average score of 4,4/10, most of the participants have a MDD-W score between 4 and 6. However, it is noticeable that more women had low scores, such as 2 or 3 compared to those with scores higher than 7, especially for Mukta-Kamaiya which represent most of women having scores between 2 to 4 out of 10.

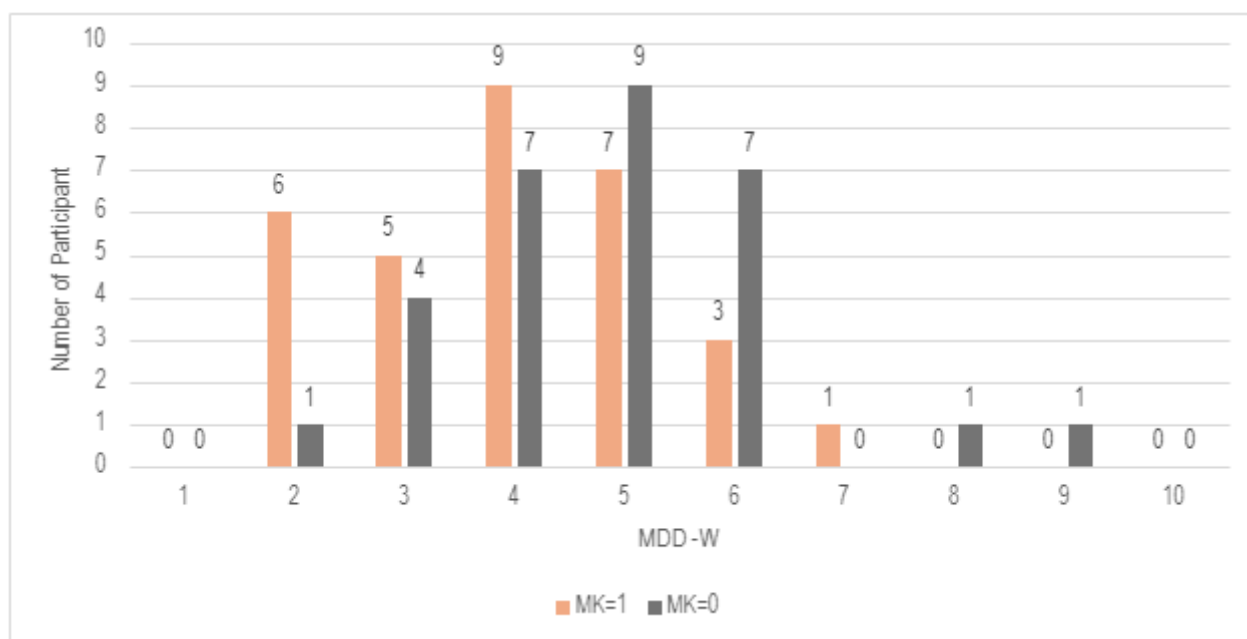


Figure 6 Distribution of MDD-W Scores Among Participants (disaggregated between MK and non-MK)

MDD-W analysis showed that around 11% of the population had a low dietary diversity, 40% a moderate one and 42% an acceptable one. No more than 5% had a high or very high dietary diversity.

Secondly, the MDDW scores for the entire population were tested for normality and then treated with a t-test. The responsive variable was chosen to be the MDDW scores meanwhile the explanatory variable was the Mukta-Kamaiya Affiliation. The null hypothesis (H0) stating "There are no differences in MDDW scores between the two groups" was rejected, and the alternative hypothesis (H1) stating "There is a difference in MDDW scores between the two groups" was accepted. This conclusion was based on the Satterthwaite method, which gave a p-value of 0.0073 ($Pr > |t| = 0.0073$). The mean MDDW score for the Mukta-Kamaiya group was found to be one point lower (3.9) than that for the Non-Mukta-Kamaiya group (4.9). Therefore, MDDW scores are significantly lower for the freed bonded labourers.

3.3.2 Differences in Food Group Consumption between MK and Non-MK

The food group consumption analysis by Mukta-Kamaiya Affiliation unveils different patterns. Non-Mukta Kamaiya women show to have a greater consumption of pulses, dairy products, meat,

eggs, and fruits compared to Mukta-Kamaiya. For instance, while 80% of Non- Mukta-Kamaiya consumed pulses, only 66% MK did. Similarly, 50% of non-MK consumed dairy products, compared to half this percentage for MK. Both of them showed poor consumption of meat, poultry and fish, as well as eggs, which groups were even less consumed by MK. However, no differences are shown for grain consumption, nuts, vitamin A-rich vegetables, overall vegetables. Mukta-Kamaiya women had a larger consumption of dark leafy vegetables.

Rice, as a staple grain, requires a separate consideration as it is highly consumed in South Asia with a median of 630g/day of white rice (Balaji *et al.*, 2020). It is noted to be a primary source of energy. In this study, Mukta-Kamaiya women derive 58% of their daily energy intake (kcal) from rice, while 48% of Non-Mukta-Kamaiya women's energy intake was sourced from rice. These high intakes of white rice reflect of the food traditions and product availability of the area.

3.3.3 Food Group Consumption Classification

Based on a similar reflexion as for the first classification, it was considered relevant to explore potential trends in the food group consumption and find if a classification could be made.

a. Outlier identification

Using the same procedure as for the first outlier identification, five outliers, were detected when studying the variables of the consumption of the ten food groups. These outliers were excluded from the later dietary diversity analysis, resulting in a population of 28 Mukta-Kamaiya and 28 Non-Mukta-Kamaiya women. Notably, Non-Mukta-Kamaiya outliers had high MDDW Scores while Mukta-Kamaiya outliers had lower scores.

b. Clustering Classification

The first step of this classification aimed to understand the number of clusters, or groups, to create. For this, the clustering procedure on SAS Software was implemented. According to the results for the three statistical values: CCC, Pseudo-F and Pseudo T-Squared, it was decided that three clusters should be created. Subsequently, the k-means procedure was used to segment the participants between the clusters based on their consumption of the 10 food groups studied.

The following Table 3 presents the characteristics of each diet of the clusters:

Table 3 Food Group Consumption Trends for each Cluster

Cluster	Size	Food Group Consumption Differences	Proportion of MK/NON-MK	MDDW Score
1	28	Lower consumption of Pulses, Higher consumption of Dairy products, Higher consumption of vegetables.	MK: 13 Non-MK: 15	4,2

2	9	Higher consumption of Dark green leafy vegetables, Higher consumption of Vitamin A-rich fruits and vegetables.	MK: 6 Non-MK: 3	4,4
3	19	Higher consumption of meat, poultry and fish products.	MK: 9 Non-MK: 10	4,3

The three clusters show no significant difference in the population composition between Mukta-Kamaiya and Non-Mukta-Kamaiya women, nor do they exhibit different trends in the socio-demographic variables. Nevertheless, distinct food group consumption patterns were determined. The first cluster, the most representative of the population, is characterized by a low consumption of pulses and a high consumption of dairy products and vegetables. The second cluster, representing only 16% of the population, presented a high consumption of dark green leafy vegetables and vitamin A-rich fruits and vegetables. The third cluster, the second more populated, represented participants with a high consumption of meat, poultry and fish products.

3.4 Food determinants and Socio-Demographic Influences on Nutrient Intake and Dietary Diversity

Food determinants and socio-demographic influence on dietary patterns is crucial to understanding the nutritional patterns within population. Hence, this section investigates if the determinants of women's food consumption vary based on their community affiliation, through two sub-questions:

- Are there differences in the determinants between the communities?
- Do these socio-demographic variables offer insights into food consumption or nutrient intake dynamics?

3.4.1 Socio-Demographic Differences between the Two Specific Communities

For the first step and to not bring wrong conclusions, no outliers were identified in the socio-demographic and individual variables.

Regarding socio-demographic and qualitative variables, not all trends differ significantly between the populations studied with both populations have a similar Food Insecurity Experience Scale (FIES). However, the mean FIES score is higher for the Mukta-Kamaiya community, indicating a more intense experience of food insecurity for this group. The Wealth Score, based on monthly household income, land size, and the number of animals in herds, does not show a significant difference in its mean between the populations. Nevertheless, there is a noticeable trend, as the T-Test results ($Pr > |t|$ with the Satterthwaite Method) are low (0.0701), indicating a lower mean Wealth Score for Mukta-Kamaiya households (10.33 compared to 13.5 for non-Mukta-Kamaiya households).

The size of owned land shows a significant difference, with Mukta-Kamaiya households owning a mean of 6.7 khatta compared to 18 khatta for other households. This difference is reflected in the mean number of crops produced, with Mukta-Kamaiya households producing an average of 4.4 crops compared to 5.6 crops in non-Mukta-Kamaiya households.

3.4.2 Socio-Demographic Influences on Nutritional Indicators

In exploring whether any socio-demographic variables explain the MDD-W scores or Mean Adequacy Ratios, no strong correlations were identified without disaggregating the population by community.

However, some patterns were noted for the entire population. First of all, the experienced food insecurity from the participants' perspective seems well justified. In fact, with a negative trend between FIES and MDD-W Scores of -0.42 , it appears that when the FIES scores increase, indicating higher food insecurity, the dietary diversity (MDD-W scores) decreases, which is expected. Additionally, education positively influences nutrient intake adequacy, showed by a positive trend between Education and Mean Adequacy Ratios of 0.40 . This correlation may be explained by the fact that women who are able to access to the education system longer, often experience improved wealth and health status. Otherwise, it could be that the education possibilities were directly permitted by the household status and wealth, enabling their higher dietary possibilities and adequacy as well. Finally, there is a fair positive correlation between the Mean Adequacy Ratios and the MDD-W Score (0.60). This relationship is rational as a higher MDD-W score increases the possibility of meeting the recommended nutrient intake.

More specifically, for non-Mukta-Kamaiya women, the correlation analysis revealed several relationships between dietary diversity and socio-demographic trends. Firstly, there is a negative trend (-0.49) between MDD-W and FIES demonstrating that a higher food insecurity is associated to a lower dietary diversity. A small positive correlation trend between Mean Adequacy Ratios and Wealth Score (0.50), and between MDD-W Score and Wealth Score (0.55) revealed that wealthier women had a preferable dietary diversity and a higher nutrient intake adequacy. Positive trends between Mean Adequacy Ratios and Education (0.54) and between MDD-W and Education (0.43) pictured that education is positively associated to dietary diversity and nutrient intake adequacy. Lastly, nutrient intake adequacy seems related to dietary diversity, as a positive correlation between Mean Adequacy Ratios and MDD-W Score (0.66) has been noted. Nevertheless, no significant correlations were observed for Mukta-Kamaiya women.

3.5 Food Taboos and Realities

Socio-demographic factors are not the only influences on dietary patterns, cultural and inter-generational food taboos play a role in framing dietary habits. The interviewed women reported sometimes to have restricted diets during pregnancy and breastfeeding. Myths, taboos, and misinformation can influence these dietary patterns. Therefore, debunking these ideas and raising awareness about observed food taboos could help women to have achieve a more diverse diet during these crucial periods for infants' development. Overall, it was noted that many of the food avoided during pregnancy and breastfeeding were not supported by any scientific evidence. Several women avoided fish, bottle and ash gourd, chilies, curd, papaya, eggs and jackfruit, among others products. However, all these foods can be safely consumed during these periods of life, provided they are of good quality and, in some cases, properly cooked (eggs, fish).

3.6 Nutritional Knowledge: Comparison of Results with Self-Perception

Self-perception of food consumed, including variety and quantity, often differs from the actual nutritional needs of the body. Therefore, understanding these needs is crucial to improve eating habits.

In fact, notable differences between Mukta-Kamaiya and non-Mukta-Kamaiya women were noted in their self-assessment of whether their food consumption met their nutritional requirements, in terms of quantity and variety. While 80% believed eating enough, only 50% of the women actually did, with Mukta-Kamaiya showing broader discrepancies between their self-perception and actual food intake. Furthermore, 80% of the participants were mistaken about the variety of their diets. 22% of the women did not give consistent responses regarding quantity and variety, which are often related but were viewed separately by many.

When it comes to specific food groups, both MK and non-MK women felt they were consuming sufficient amounts. However, only 48% met fish consumption guidelines, and just 20% ate fruit daily. Additionally, 72% of the participants did not consume dairy products daily. Mukta-Kamaiya persistently consumed less of these three food groups than non-Mukta-Kamaiya. However, both groups were often incorrect in their assessment of dietary adequacy.

3.7 Eating Habits

Finally, the collected data on meal frequency indicated that most women ate three to four meals daily, with 57% snacking regularly, and preferably home-cooked meals due to economic or cultural reasons, particularly in the MK group. These findings emphasize the greater nutritional challenges faced by MK women and the need for targeted education and support.

IV. Discussion

4.1 Segmented Based on Results

The data analysis provided key insights into the nutritional dynamics of the population and their differences (Mukta-Kamaiya and non-Mukta-Kamaiya groups). The Mukta-Kamaiya group showed deficiencies in energy, fibre, calcium, iron, copper, zinc, and several B vitamins (B1, B2, B3, B5, B9, B12), as well as vitamins A, E, and D. Both groups displayed high results for fat, protein, magnesium, sodium, selenium, and vitamins C and K, contradicting assumptions of energy and protein deficiencies. Therefore, the nutrient results suggested that both groups under-consumed certain food groups, such as dairy (calcium and vitamin D deficiencies) and iron-rich foods (iron and B vitamin deficiencies). The MK group, however, displayed a broader deficiency, potentially due to a lack of access to nutrient-dense foods like meats, fish, nuts, seeds, and a variety of fruits and vegetables. With these gaps identified, examining the consumption of food groups through the MDD-W detailed score provides further explanations. Similarly deduced from the nutrient intakes, Mukta-Kamaiya group in fact consumed fewer pulses, dairy products, meat, eggs, and fruits. Beyond these differences, overall food group consumption patterns were not significantly different between the groups.

The lack of a strong correlation between MDD-W scores and Mean Adequacy Ratios, indicated that consuming a variety of food groups did not always guarantee sufficient nutrient intake and vice-versa and suggested that the issue may not only be about the variety of foods but also the quantity consumed. The 15 grams threshold used for MDD-W scoring may not fully capture actual nutritional needs. Additionally, the MK group had a lower average energy intake, with a higher reliance on rice, reducing intake from other, more nutrient-rich, food groups. Moreover, these differences could also be a consequence from products variety within food groups consumed. The Mukta-Kamaiya might rely on less nutrient-dense foods within the same food group, leading to poorer nutritional outcomes. Factors such as nutrient bioavailability, food quality, and cooking methods likely play a role as well, although not analysed in this study, suggesting they were considered unvaried for all individuals.

Health impacts for the MK groups deficiencies and diets include risks like chronic fatigue, poor immune system, poor bone health, anaemia, and vitamin deficiencies, potentially leading to conditions like beriberi (deficiency in thiamine) and skin disorders. These health issues could affect maternal mortality, birth outcomes and milk production. Non-Mukta-Kamaiya women mostly face major risk of health issues due to calcium and iron deficiencies (Tulchinsky, 2010).

The difficulties for Mukta-Kamaiya to consume enough of certain food groups are linked to affordability (poor incomes), availability, accessibility and desirability (knowledge limitations, position of stepmothers restricting desirability).

On a statistical level, the study explored some socio-economic factors, finding that higher food insecurity was linked to lower dietary diversity (MDD-W scores), and higher education levels correlated with better nutrient intakes. However, an association between MDD-W and wealth was only observed in the non-MK group, indicating that economic factors might play different roles in each group. These differences might exist for different reasons. One possible explanation could be the unique socio-economic composition of the Mukta-Kamaiya group, where economic variables and food access determinants are influenced by a complex interplay of factors, including cultural, psychological, and social elements. For instance, Mukta-Kamaiya communities might face deep-rooted socio-cultural practices, psychological stress or marginalization.

Thus, the study suggests that strong statistical correlations between dietary indicators and socio-economic factors, not only wealth, are difficult to establish due to the many influencing variables – eating determinants.

Overall, several specific determinants influencing dietary patterns were identified through this study. Key factors considered the significant position of the stepmothers in the decision-making process, a lack of nutritional knowledge (acknowledge by the participants), and the restrictive diet due to physical conditions. However, these influences were observed but not quantitatively scored. Among the determinants scored, it seemed that Mukta-Kamaiya faced even bigger challenges because of smaller owned lands, poorer incomes and overall wealth as well as underlaying societal stigma. All participants seemed to be heavily influenced by household dynamics, eating habits (such as food taboos and traditions), and economic constrains (like food expenditure and income). In fact, while the average Nepali monthly income is around 80,900 NPR (Ministry of Labour, Employment and Social Security [MoLESS], n.d.), the mean monthly income was less than half of this amount for the studied population. These observed differences between the two groups were marked in the Appendix L.

The data collected brought forward that affordability and desirability are the main constraints impacting food dynamics. Nevertheless, these results are logical as accessibility and availability were not statistically assessed and that the women did not discuss about these factors, possibly because of a lack of comprehension of the broader food determinants. This highlights the need for assessing most, if possible, of the eating determinants which could not be scored and used in the statistical analysis for this study.

4.2 Discussion on the Cost of a Healthy Diet in Nepal

The discussion on the cost and affordability of a healthy diet in Nepal is especially applicable to the Mukta-Kamaiya group. A healthy diet, considered as providing more than just energy from carbohydrates and staples, remains unattainable for many due to economic constraints. In fact, the

minimum cost of a recommended diet (CoRD) in Nepal was estimated at \$1.80 per person per day in 2011. However, 55% of households were spending less than this amount on food, indicating they possibly could not afford a healthy diet (Dizon *et al.*, 2021).

For Mukta-Kamaiya, limited income poses a significant barrier to purchasing a variety of nutrient-rich foods, such as pulses, dairy, meat, eggs, fruits, fish, and nuts, further challenged by the variability in food prices, particularly for fruits and vegetables, which are the most expensive and least accessible food groups. Researchers showed that households in Nepal, including those of the Mukta-Kamaiya, tend to overspend and overconsume on starchy staples (spending 24% more than needed according to CoRD) and fats, while under-consuming fruits (meeting only 38% of FBDG) and vegetables, which are essential for a balanced diet. This study also indicated that households overspend on dairy products but only met 65% of FBDG requirements, possibly due to purchasing more expensive choices. A similar pattern was observed with protein-rich foods (Dizon *et al.*, 2021).

The affordability of food varies significantly depending on geographic location, market access, and socio-economic conditions, which is more restrictive for the Mukta-Kamaiya due to their rural setting and lower income levels, even though the CoRD is lower in rural regions (\$1.70). In the Bheri Administrative Zone, which includes Bardiya District, 50% to 60% of households spent less than the assessed CoRD of 50 to 60 NPR (Dizon *et al.*, 2021).

As a matter of fact, the affordability of a healthy diet is influenced by both incomes and prices, both varying by location. In urban areas, higher food prices are the main issue, while in rural areas, lower incomes are the primary restriction. Food prices fluctuate significantly across Nepal especially for fruits (29%) and vegetables (27%), followed by dairy products, starchy foods, and protein foods (Dizon *et al.*, 2021), further increasing vulnerability, particularly for the Mukta-Kamaiya. Seasonal variations also impact the cost of a healthy diet, with higher costs during the monsoon season. These fluctuations are partly due to agricultural seasons and exacerbated by extreme weather and climate change, affecting supply chains through floods and landslides (Dizon *et al.*, 2021).

It is evident that enhancing the affordability and accessibility of a diverse range of nutritious foods is crucial for enabling a healthier diet, particularly for the Mukta-Kamaiya. Interventions should aim to increase incomes, improve market access, and stabilize food prices, especially for fruits and vegetables, to improve diet quality and reduce nutritional deficiencies in this vulnerable population.

4.3 Importance of Rice in the Diet

As the findings and literature review demonstrated, the reliance on starchy foods, and mainly white rice, is significant, from which around 50% of the energy consumed was derived. While carbohydrates should indeed make up for a substantial amount of the diet and represent 45% to 65%

of the total calories consumed (Ryan-Harshman & Aldoori, 2006), there still should be a variety of types consumed. However, the Nepali population, including the Mukta-Kamaiya, heavily depends on white rice, even though other several more nutritious types of rice may be available.

Notably, given its importance in the diet, many nutrients, including proteins, are sourced from this staple food. However, white rice is known to lack of essential nutrients, generally containing only 7% proteins, providing less than pulses and wheat (Zafar & Jianlong, 2023). Its composition in essential amino acids is concerning, particularly lysine, which is crucial for building blocks of protein. Additionally, beta-carotene, vital for vitamin A production, is not found in standard varieties of rice, and the content in iron and zinc are insufficient to meet the nutritional requirements (Zafar & Jianlong, 2023). Evidently, the nutritional content of rice can vary depending on the variety, harvesting conditions, and environmental factors related to growing, processing, and storage. In opposition to white rice, brown rice, is known to contain higher portions of proteins, fatty acids, vitamins and minerals, provided by the brown layer. This variety offers almost four times the phosphorus of white rice and contains more fats, despite having lower levels of folates and iron. Other varieties provide interesting nutrients, as red rice and black rice, and biofortified rice, which can be enriched with lysine, beta-carotene, folate, iron and zinc, among other nutrients (Zafar & Jianlong, 2023).

Therefore, there is a need to change towards more nutritious varieties of rice, natural or enriched, to address the white-rice-dependency. Nevertheless, cultural preferences and traditions impose white rice being as a staple product for centuries and is preferred due to its cultural significance, taste, texture and ease of preparation (FAO, 2004). Furthermore, white rice is often more affordable and available, due to its simpler, less delicate and less expensive processing (Hossain & Narciso, 2004). Because of the poorer oil content, storage is longer and easier, advantaging rural households that have limited access to markets and limited storage facilities (Roy *et al.*, 2008).

4.4 Limitations and Challenges

There were several limitations in this study, affecting each stage of the research process. Firstly, the use of a simple and single 24-hour dietary recall to assess participants' food intake did not capture variations in daily consumption, seasonal changes, or potential recall bias or misrepresentation (as it was based on self-reported data). Additionally, the sampling method did not accurately represent the targeted population and ethnicities, as it was based on what was feasible. Thus, certain dynamics and patterns could have been overlooked. Also, the analysis was limited by the RDAs used and the available food composition table, which did not cover all nutrients.

Regarding the data collected, additional questions could have provided a more complete understanding of their context, but the limited time for data processing did not allow for a heavier

data collection. Participants were not asked if they were taking any supplements, even if assessing the quantities absorbed and composition of the supplements would have been difficult

Moreover, the study did not collect information on the participants' weight before pregnancy, making it challenging to study weight gain and overall health. For the data on crop production, it would have been interesting to ask about the exact varieties grown, as different varieties have different nutritional compositions. Understanding their crop rotation, the amount consumed versus sold, and the income generated from each crop could also provide valuable insights. However, obtaining this information would certainly have been difficult due to the participants' limited knowledge or lack of calculations regarding these details. Also, it was not confirmed whether the participants had property titles for their land or if they owned it without documentation or rented it. Investigating this could be important, as challenges with land ownership can limit access to loans, credit, land investment, and cause instability.

Data translation had some limitations; the food composition was often based on a recipe from a Food Composition Table, overlooking individual differences. There were also challenges with portion sizes and calculating recipes, leading to some inaccuracies. However, these inaccuracies would affect everyone equally, meaning the overall patterns should still hold. Subsequently, the data analysis faced challenges in accurately interpreting the collected data due to its reliance on self-reported information. This is particularly relevant for socio-demographic and economic data, where inaccuracies or exaggerations could impact the findings. Moreover, the analysis implemented was relatively simple and might not have gathered all relevant information resulting from the data.

Finally, the results revealed some unexpected findings and raised further questions. Selenium and sodium levels appeared to be unusually high, which could be due to potential inaccuracies in the food composition table, calculation errors or because of dietary habits of the participants. Moreover, the socio-economic and demographic analysis did not provide clear explanations for the dietary recall findings. This could be because the living conditions varied among each group or because dietary choices are influenced by a combination of multiple factors rather than just one. As a result, it was difficult to determine the importance of each food determinant, particularly since many of these factors were only addressed in the literature review and not directly analysed in the study data.

Conclusion

To conclude this six-month research study, it was demonstrated that pregnant and lactating women in Mainapokhar Village, Bardiya District, Nepal, show deficiencies in several specific nutrients and face relatively inadequate dietary diversity. Women from the Mukta-Kamaiya community experience broader nutritional gaps and greater challenges in accessing nutrient-dense products, such as dairy, fruits, and animal products. Therefore, their nutritional status appears more precarious compared to other communities in the studied area.

No significant influence of socio-demographic and economic factors on dietary intake was noted. However, wealth and educational levels seemed to contribute positively to nutritional outcomes in the other communities, suggesting a potentially more multi-faceted and complex situation for the Mukta-Kamaiya. Notably, factors such as smaller land size and lower overall household income were more common in the Mukta-Kamaiya community, potentially impacting their diets. They also face a challenging societal status due to their past as labourers, further exacerbated by the lack of freedom in land management imposed by the government.

Across both populations, determinants of eating behaviours were identified, fluctuating from family dynamics and cultural beliefs to poor nutritional knowledge, which limit access to adequate food. Moreover, income and wealth difficulties further restrict food availability. The study highlighted the prevalence of varied food taboos and a lack of understanding of nutritional needs among all women. The role of the stepfamilies is crucial, and they should be taken into consideration to tackle generational cycle of nutritional challenges. This study and literature review also brought forward the dominant impact of food affordability on these communities, especially for poorer households such as the Mukta-Kamaiya, whose smaller lands, crop production and income levels make them more vulnerable to prices fluctuations. Nevertheless, facing these latest challenges, Mukta-Kamaiya women might face more difficult family dynamics because of societal marginalization, potentially reducing their empowerment within households. To conclude on these eating determinants, the original Figure 2 was revised to reflect the results and is now presented in Appendix L.

This research raises a wider theme about predeterminism of choice, which suggests that individual decisions are framed by various factors, such as those identified as eating determinants in this study. Therefore, interventions should not only focus on individuals' free will but also consider the environment influences and pre-existing conditions that impact their possibilities and, in this context, food desirability. A suggestion document was developed for FAO Nepal to guide the implementation of tailored nutritional interventions for pregnant and lactating women in the Bardiya District, and is available in Appendix N.

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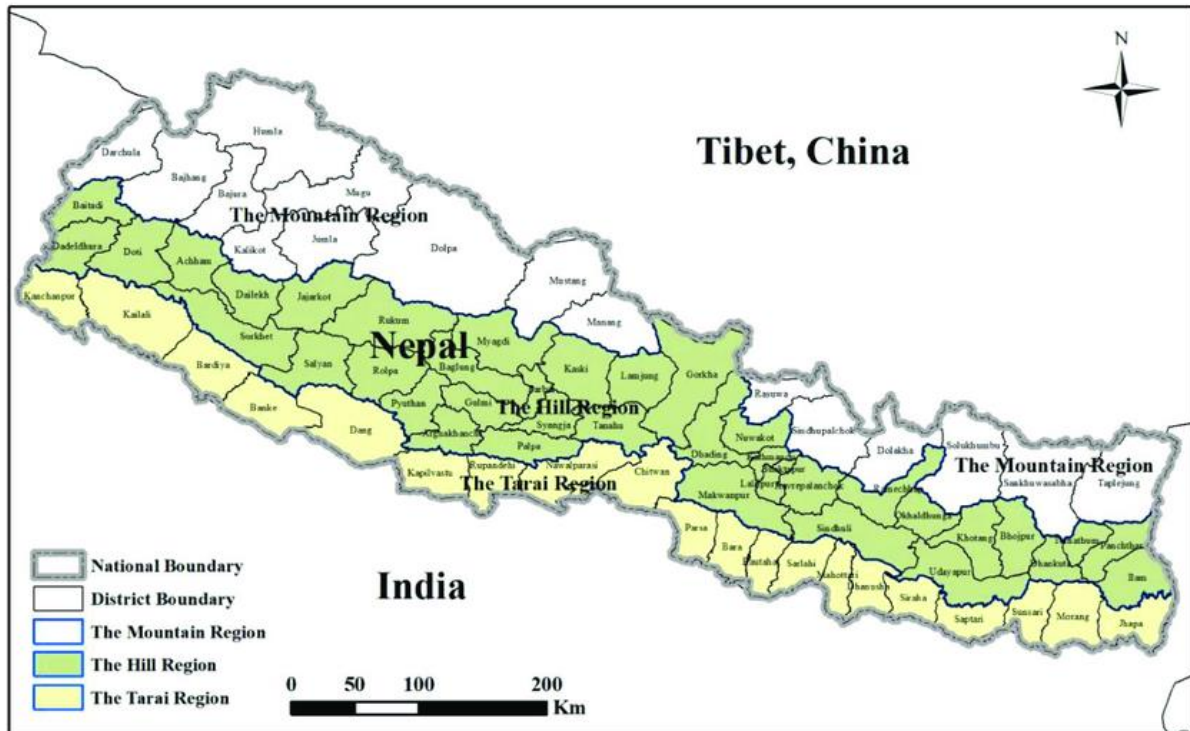
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Appendices

Appendix A - Map of the Ecological Zones of Nepal



(Liu et al., 2023)⁵

⁵ Liu, Y., Yang, Y., Zhang, C., Xiao, C., & Song, X. (2023). Does Nepal have the agriculture to feed its population with a sustainable diet? Evidence from the perspective of human–land relationship. *Foods*, 12(5), 1076. <https://doi.org/10.3390/foods12051076>

Appendix B - Table of the Factors influencing Affordability, Accessibility, Availability and Desirability of Food

DETERMINANT	ECONOMIC DETERMINANTS (NATIONAL LEVEL)	ECONOMIC DETERMINANTS – HOUSEHOLD LEVEL	BIOLOGICAL DETERMINANTS	SOCIAL/SOCIETAL DETERMINANTS
AFFORDABILITY	Market Price (International Trade, Local and National Production)	Access to credits or loans	Seasons	Employment
	Inflation	Traditional Wealth (including Income Level)		Education
	Policies (subsidies and government support)	Employment		Community Affiliation
AVAILABILITY	Local and National Production (agricultural practices)	Land use and Ownership	Seasons	
	International Trade (Imports and Exports)		Climate conditions	
	Policies (subsidies and government support)			
	Supply Chain Efficiency (distribution networks)			
DETERMINANT	Economic Determinants (National Level)	Economic Determinants – Household Level	Biological Determinants	Social/Societal Determinants

ACCESSIBILITY			Transportation Means and Road Infrastructures	Social Network
			Household Isolation / Distance to markets	Political Stability
DESIRABILITY				Cultural preferences, eating habits (culinary traditions, food taboos and restrictions)
				Nutritional Knowledge Communication (advertisement, media, health campaigns...)

Appendix C - Key Variables for the Study

Category	Variable Names
Nutrition	Nutrient intake Consumption of food groups
Demographics	Weight Height Ethnicity Marital Status Pregnancy and Lactation Status Education Level Employment Status Village Residence Reason ⁶
Household Information	Household Head Member Household Head Job Household Size Number of Girls Number of Boys Monthly Income Monthly Food Expenditure Income Allocation to Food Responsibility Primary Cook Food Purchaser Income Allocation to Food Sufficiency
Land and Agriculture	Land Ownership Land Renting Land Size Crop Production Crop Use
Livestock Information	Livestock Ownership Herd Type

⁶ What was the reason for living in this specific area

	Herd Size
	Livestock Use
Physical Activity	Physical Activity Level
Dietary Dynamics	Eating Hierarchy Diet Related Diseases Meals Per Day Meals At Home Breakfast Consumption Eating Out Frequency Snacking Frequency Diet Quantity Adequacy Perception Diet Quality Adequacy Perception Insufficiency Reason ⁷ Perceived Intake Adequacy for: Salt, Fat, Meat, Fish, Fruit and Vegetable, Dairy products Food Taboos
Food Security	FIES Score (Food Insecurity Experience Scale)

Appendix D – The Ingredient Method

The Ingredient Method consists in taking into consideration the Edible and Yield factors. The Edible Factor considers the weight of the item after all waste has been removed (ex: the peel of carrots). The second one evaluates the weight change of the ingredient after being cooked, influenced by the cooking method (boiled, fried, stewed, grilled...). For instance, some ingredients lose water due to evaporation, while others expand due to water absorption (ex: rice). Another critical factor to take into consideration is the Nutrient Retention Factor. According to the cooking method, the nutrients present in the raw ingredients are more or less degraded. These changes must be calculated for more precision during the nutrient intake adequacy study. The following steps, provided by the European Food Information Resource (EuroFIR, 2014), bring insights into the calculation method:

⁷ In case of diet quality or quantity inadequacy perception

(1) The final weight of the recipe was calculated by multiplying the raw portion of each ingredient to its yield factor (YF) and then summing the weights of all cooked ingredients.

(2) The nutrient composition of the recipe was calculated by multiplying the nutritional value for 100g by the actual raw portion of each ingredient, dividing by the total weight of the whole recipe, and multiplying by the nutrient Retention Factor (RF), according to the ingredient and cooking method. The nutrient values for each ingredient are summed to determine the final nutrient composition per 100g of the recipe.

(3) Finally, to determine the nutrient intake based on the portion consumed by the participant, the final nutrient composition per 100g was multiplied by the actual portion size consumed.

The final formulas of the Ingredient Method for calculating a recipe's nutrient composition were:

(1) Ingredient 1, nutrient X: $NV \times (\text{Raw weight of ingredient (g)} / \text{total cooked weight of the recipe}) \times RF$

(2) Ingredient 2, nutrient X: $NV \times (\text{Raw weight of ingredient (g)} / \text{total cooked weight of the recipe}) \times RF$

(3) Repeat for all ingredients and all nutrients

(4) Recipe composition for 100grams: Sum of the above, for each nutrient

(5) Multiply by the portion size consumed

With:

- NV: Nutritional Value for 100g of the raw ingredient
- Yield factor (YF): Percentage weight change in foods or recipes due to cooking.
- Nutrient retention factor (RF): Percentage retention of nutrients, especially vitamins and minerals, in food or dish after processes such as storage, preparation, processing, warm holding or reheating.

These factors were found on the Tables on weight yield of food and retention factors of food constituents for the calculation of nutrient composition of cooked foods (dishes) (Bognar, 2002), where the Yield factors comprehended the Edible Factors.

Appendix E – Table for Household Decision Making Power Scoring

A scoring system was elaborated to understand the decision-making power of the participants, mostly in regard to food. It was assessed according to their role and influence, as provided by Table X.

Person	Scoring According to Position		
	<i>Household Head</i>	<i>Person Deciding Income Allocation to Food</i>	<i>Person Cooking</i>
Participant	4	3	1
Someone else	0	0	0

A ponderation was given according to the role related to food. If the participant was considered the household head, i.e. the person making most decisions in the household, a score of 4 was given. If the participant was the one deciding which amount of income is allocated to food purchases, the score was 3 and if she was the person cooking, a score of 1 was given. The person responsible for shopping was not considered in the scoring process as it fluctuated depending on the day. Finally, the higher the sum of the three scores was, the greater the decision-making power and influence over decisions regarding food was for the participant.

Appendix F – Table for Food Dynamics Scoring

This procedure assessed the household's eating order and the monthly monetary allocation to food per person, which was calculated upon the household's monthly income and the number of people per household. It was supposed that this monetary allocation would be the same for everyone. Both variables contributed to a score assessment, as given by Table

Eating Rank		Monthly Money Allocation to Food per Person	
<i>Modality</i>	<i>Score 1</i>	<i>Modality (NPR/Person/Month)</i>	<i>Score 2</i>
Eats first / All together	1	0 to 500	7
Eats second	2	500 to 1000	6
Eats third	3	1000 to 2000	5
Eats fourth	4	2000 to 3000	4
Eats Fifth	5	3000 to 4000	3
		4000 to 5000	2
		5000 to 6000	1

The sum of both scores gave the overall indicator value. A lower score indicated that the household food dynamics were beneficial for the participant.

Appendix G - Food Insecurity Experience Scale (FIES) Questions by Severity

Questions	Label	Domains of FI construct	Assumed severity of Food Insecurity	Score
Q1	WORRIED	uncertainty and worry about food	Mild	1
Q2	HEALTHY	Inadequate food quality	Mild	1
Q3	FEWFOOD	Inadequate food quality	Mild	1
Q4	SKIPPED	Insufficient food quantity	Moderate	2
Q5	ATELESS	Insufficient food quantity	Moderate	2
Q6	RUNOUT	Insufficient food quantity	Moderate	2
Q7	HUNGRY	Insufficient food quantity	Severe	3
Q8	WHLDAY	Insufficient food quantity	Severe	3
			Max	15

(Sheikomar et al., 2021)

Appendix H - NAR, MAR, MDD-W and Rice Consumption Indicators Calculation Methodologies

(1) The **Nutrient Adequacy Ratio** is calculated for each nutrient studied using the following formula, as outlined by Gibson (2005):

$$\text{Nutrient Adequacy Ratio} = \text{actual intake} / \text{recommended intake}$$

(2) The following is the formula for calculating **Mean Adequacy Ratio** (INDEXX (n.d)):

$$\text{MAR} = \frac{\text{Sum of NAR}}{\text{Number of nutrients}} \times 100 \text{ (if representing as a percentage)}$$

(3) The following paragraph explains in further details **MDD-W** theory and calculations:

These food groups are (1) Grains, white roots and tubers, (2) Pulses, (3) Nuts and seeds, (4) Dairy products, (5) Meat, poultry, and fish, (6) Eggs, (7) Dark green leafy vegetables, (8) Other vitamin A-rich fruits and vegetables, (9) Other vegetables and (10) Other fruits. By identifying how many items from these food groups were consumed in the past 24 hours for women in reproductive age (15 to 49 years old), in which pregnant and lactating can be counted, a score from 1 to 10 can be given. MDD-W is a dichotomous indicator, meaning that this score can only take two values, in this case “consumed” (yes) or “not consumed” (no). In fact, for this indicator, a food group is supposed to be consumed if at least 15 grams of it was consumed during the period studied. As the MDD-W score is based on the exact quantity of each food groups within a period of 24 hours, it permits to assess the nutrient intake’s quality of a person and on a broader level, it could be used for a population-level intake assessment (Women’s Dietary Diversity Project, 2017).

(3) The formula for the **Rice Indicator** is the following:

$$\text{Rice Consumption Indicator (\%)} = (\text{Energy (kcal) from rice} / \text{Total daily energy intake (kcal)}) \times 100$$

Appendix I - Descriptive Statistics of the main Socio-Demographic Variables compared between MK and non-MK

Variables	Modalities	Mean value	Standard deviation	Minimum Value	Maximum Value
Wealth (score)	MK	6.9	3.7	1	15
	Others	9.1	3.6	4	18
	All	8	3.8	1	18
Monthly income (NPR)	MK	31,400	24,718	8,000	120,000
	Others	36,207	39,143	6,000	200,000
	All	33,762	32,420	6,000	200,000
Size of Land (khatta)	MK	10.4	19.1	0 ⁸	15
	Others	15.8	19.1	0 ⁹	80
	All	13	19.1	0	80
Length of Land Ownership (years)	MK	19.4	17	0 ⁸	50
	Others	16.2	14.4	0 ⁹	50
	All	17.9	15.7	0	50
Animals owned (n)	MK	12	9.27	0 ⁸	43
	Others	9.9	12.2	0 ⁹	50
	All	11	10.8	0	50
Crop produced (n)	MK	5	1.6	0 ⁸	8
	Others	5	1.9	0 ⁹	8
	All	5	1.8	0	8
Decision-making power (score)	MK	1.3	0.7	0	3
	Others	1.2	0.7	0	3
	All	1.2	0.7	0	3
Food Dynamics (score)	MK	5	1.6	1	9
	Others	4.2	1.7	1	8
	All	4.6	1.7	1	9
Number of People per household (n)	MK	5.1	1.6	2	9
	Others	5.4	1.9	2	9
	All	5.3	1.8	2	9

⁸ 5 Mukta-Kamaiya Households did not own a land, 3 did not own animals

⁹ 7 non-Mukta-Kamaiya household did not own a land, 3 did not own animals

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Appendix J – Crop Production, Livestock Ownership and Usages

Table: Main Crop Production by Group (MK and non-MK)

Crop	<i>Mustard</i>	<i>Vegetables</i>	<i>Rice</i>	<i>Wheat</i>	<i>Maize</i>	<i>Potatoes</i>	<i>Legumes</i>	<i>Others</i>
<i>MK</i>	75%	92%	100%	61%	68%	25%	54%	25%
<i>Others</i>	68%	71%	100%	93%	70%	19%	58%	19%
<i>All</i>	70%	80%	100%	76%	68%	22%	56%	20%

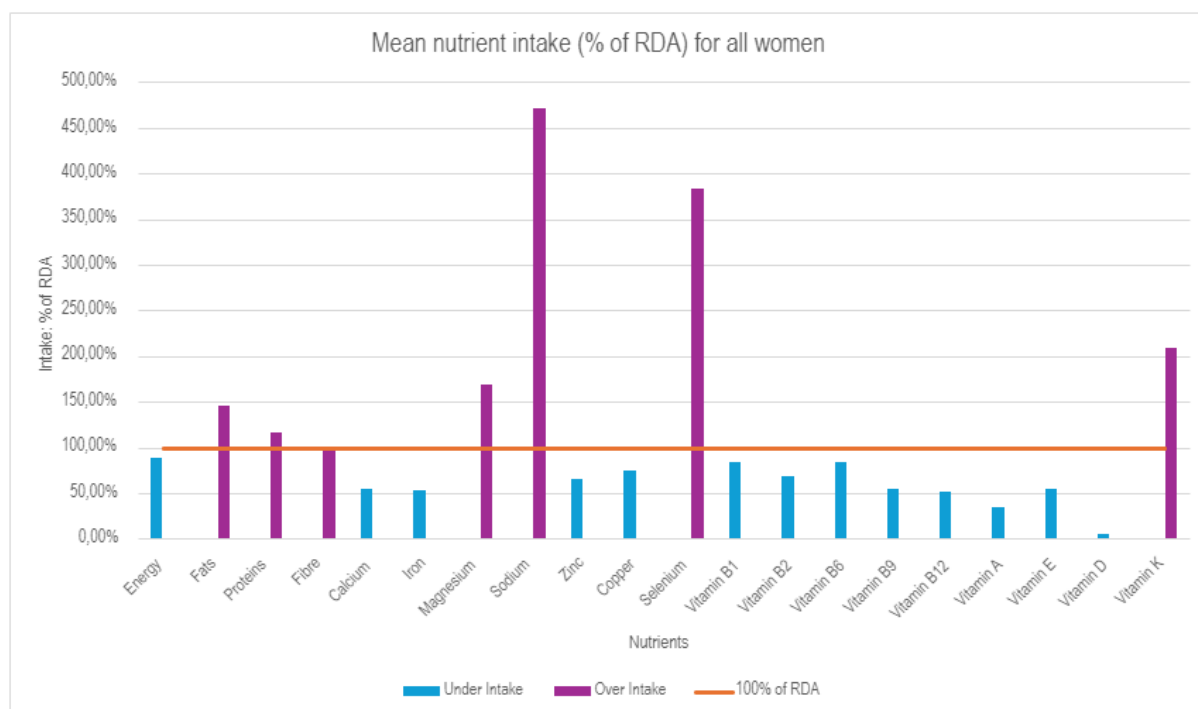
Table: Main Livestock Ownership by Group (MK and non-MK)

Livestock	<i>Cattle</i>	<i>Buffaloes</i>	<i>Muttons</i>	<i>Goats</i>	<i>Pigs</i>	<i>Fowls</i>	<i>Milk-cows</i>	<i>Milk-Buff</i>	<i>Laying Hen</i>	<i>Laying Duck</i>
<i>MK</i>	11%	36%	4%	57%	0%	36%	0%	3%	35%	39%
<i>Others</i>	33%	48%	7%	55%	11%	48%	19%	15%	33%	22%
<i>All</i>	22%	42%	5%	56%	%	42%	9%	9%	34%	30%
					5%					

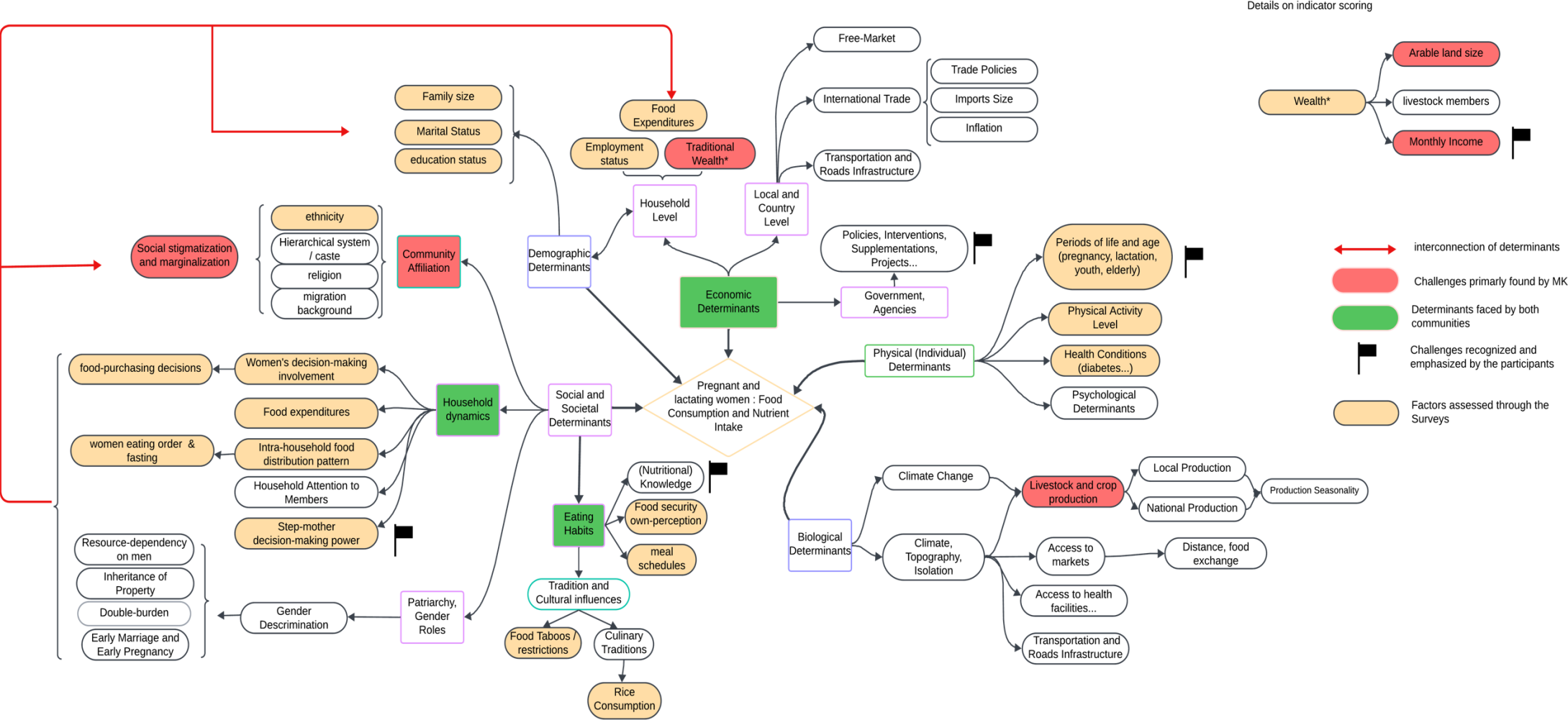
Table: Crop and Livestock Use by Group (MK and non-MK)

Crop Use	<i>Sell only</i>	<i>Consume only</i>	<i>Both</i>
<i>MK</i>	10%	60%	30%
<i>Others</i>	10%	39%	51%
<i>All</i>	10%	56%	41%
Livestock Prod Use			
<i>MK</i>	4%	50%	42%
<i>Others</i>	4%	33%	66%
<i>All</i>	4%	41%	54%

Appendix K – Figure of the Mean Nutrient Intake (% of RDA) for all Women (Non-Disaggregated Between MK and Non MK)



Appendix L – Figure representing the Eating Determinants after the Study (Emma Opitz, 2024)



Appendix M - Definitions

Accessibility: Stable availability of affordable, nourishing and suitable foods. It refers to both economical and physical access.

Affordability: It is considered as the ratio of food prices to wage. Thus, the capacity to pay market foods.

Availability: The availability of sufficient quantities of food of appropriate quality, supplied through domestic production or imports, including food aid (FAO). It addresses the “supply side” of food security.

Bonded Labour: It can be defined in two categories, the first one is debt bondage and the second one is serfdom – when someone is bound to reside and work on the land of another landowner due to law, custom or contract, and that is not free of changing his status, as per the United Nations Supplementary Conventions on the Abolition of Slavery, the Slave Trade, and Institutions and Practices Similar to Slavery (1956) (United Nations 1994:210)¹⁰.

CoRD (Cost of a Recommended Diet) : Determined by calculating the minimum cost required to meet the recommended intake for seven food groups, with the total CoRD being the sum of these costs.

Debt bondage: The condition where a person is forced to work to pay off a debt, often under exploitative conditions, affecting their freedom and well-being.

Desirability: Food consumed because it is desirable, due to personal preferences, tastes, lifestyle, beliefs or knowledge, cultures and traditions.

Dietary diversity: A measure of the variety of foods consumed, often used as an indicator of a healthy and balanced diet.

Food security: All people, at all times, have physical and economic access to sufficient safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life (1996 World Food Summit).

Food taboos: Cultural beliefs that prohibit the consumption of specific foods, often affecting nutritional intake.

Home Nutrition Gardens (HNG) : Initiative encouraging the cultivation of nutrient rich crops in home gardens, which will give some tools and knowledge to empower households and improve their food security level.

Intra-household food distribution: The way food is distributed among members of a household, which can affect individual nutrition, particularly for women and children.

Khatta: It is the unit of land measuring in Nepal, and 1 Khatta is about 0.004 Hectare.

Malnutrition: Deficiencies, excesses, or imbalances in the intake of energy or nutrients (undernutrition, overnutrition, and micronutrient deficiencies), considering stunting (low height for age), wasting (low weight-for-height), and underweight (low weight-for-age).

¹⁰ **United Nations. (1994).** *Supplementary Convention on the Abolition of Slavery, the Slave Trade, and Institutions and Practices Similar to Slavery, 1956.* United Nations Publications.

Mukta-Kamaiya: A community in Nepal historically involved in bonded labor, facing societal and economic challenges that affect their food security and nutrition.

Nutrition Field Schools: A community-based intervention to teach and learn nutritional knowledge and improve nutrition-related skills (healthy eating habits, hand-on learning, problem solving)

Nutritional knowledge: The understanding individuals or communities have regarding food and nutrition, which can influence dietary choices.

Obese: Body Mass Index of more than 30.

Overconsuming: Having a higher consumption compared to the requirements.

School Nutrition Gardens (SNG): Intervention to improve nutritional knowledge in school gardens, from learning healthy eating habits to farming practices.

Socio-demographic determinants: Factors such as age, gender, marital status, and education that influence dietary intake and nutritional status.

Stepfamily dynamics: The influence of step-relatives (such as stepmothers) on household decision-making, including food distribution and nutritional decisions.

Undernourishment: Insufficient food consumption compared to the dietary energy (calories) requirements.

Undernutrition: A form of malnutrition involving deficiencies or insufficient energy, or nutrients intake compared to recommendations.

Under consuming: Having a lower consumption compared to the requirements.

Underweight: Weighing less than the expected or normal amount for someone's age, height, and build.

Varna System: In the Varna System, the population is categorized in four major groups based on their social responsibility: Brahmins, Kshatriyas, Vaishyas and Shudras. Brahmins were responsible for guiding the society in religious matters, giving importance to preserving purity and holiness, which led to distance themselves from what was considered pollution (other ethnicities) in the population. Kshatriyas were the great warriors and the society's protectors, while the Vaishyas were involved in agriculture, trade, and livestock management, and representing a significant portion of the population. Finally, Shudras were only engaged in services-related works (Parmar *et al.*, 2021).

Westerly Circulation: Distributes heat and moisture and are an important reason for the development of weather movements (cyclones), thus participating to precipitation and wind formation

Appendix N - Suggestions for the NACCFL Project

Implementation suggestions for FAO activities

Based on insights into socio-demographic influences, targeted interventions addressing socio-demographic disparities in food security and further location-specific studies could be suggested.

The NACCFL Project aims at improving the nutritional status of Mukta-Kamaiya pregnant and lactating women by the implementation of various interventions and activities: School Nutrition Gardens (SNG), Home Nutrition Gardens (HNG) and Nutrition Field Schools (NFS) whilst also implementing Behaviour Communication Change (BCC) materials to raise awareness on certain themes. Around this, this study permitted to highlight findings of the targeted population situation, both for Mukta-Kamaiya and the other communities, and thus, provide suggestions to consider during the implementation of these activities, following various topics.

In the first place, when it comes **to agricultural practices**, it was shown that most of the households did not grow enough crop varieties. Therefore, it would be beneficial to encourage vulnerable communities to produce more nutritious foods, such as legumes and vegetables, mainly for self-consumption. This approach would reduce their dependency on rice and maize production, which are considered readily available and affordable on the Nepali market. Moreover, this would enable to relieve the instability of vegetables' price variability throughout the year. Notably, many of the participants are already growing vegetables but **ensuring that the size of the land** allocated to these crops is **sufficient** and that the **varieties** chosen are **nutritious** enough is an important step.

More particularly, some vegetable varieties, such as spinach, broccoli or for legumes, lentils, chickpeas and beans, are high-yield and disease resistant, or resilient to climate variations, while providing interesting nutrients, like protein, iron and fibre as well. Moreover, nutrient-dense crops like quinoa and amaranth offer essential amino acids, iron and calcium and could be considered as alternative to rice and wheat. Small-scale trials for these crops could be implemented in home and school gardens to understand cultivation techniques and market possibilities. Bio-fortified rice or wheat crops could alleviate the carbohydrates-dependency and increase iron and zinc intakes. Root crops are recommended to meet the populations' vitamin, fibre and antioxidant needs (Annepu *et al.*, 2021). Another interesting intervention could be by improving small-scale animal husbandry to locally benefit from nutrient-rich animal products, through enhancing livestock diversity, facilitating access to veterinary services, improving livestock facilities and management. In addition, millet and sorghum could be suggested to palliate water scarcity while still providing positive nutritional outcomes (Saeed *et al.*, 2023). Finally, crop rotation and intercropping practices should be studied in these areas and enhanced through farmers' trainings, permitting improved soil health and crop yields (Annepu *et al.*, 2021).

Moreover, as it was noted that the land owned are often small, especially for Mukta-Kamaiya households, it should be important to help improving their productivity. To provide guidance on how efficiently use their land and select high-yield nutritional crops. This could be made on a community-based approach,

promoting the establishment of at-school and at-home gardens (SNG) and (HNG) which could further encourage the production of nutritious foods and hands-on learning but also should raise awareness on which crops and varieties to grow and why. Many studies have also demonstrated that knowledge on agriculture and nutrition can be brought by children, who learned it in schools, and would be more likely to influence the whole household.

Households should receive support and training to make informed decisions about which crops or products to buy from the market, which to grow for their own consumption, and which to sell. This guidance should be based on the specific affordability and availability challenges in their area (such as vegetables, fruits, dairy products, etc.) to improve both their financial situation and nutritional health.

However, while agricultural practices should be monitored and switched, raising awareness on **nutrition** is essential to assure suitable and sustainable farming choices and could be supported by Nutritional Schools or communication tools.

In this sense, cooking methods ensuring the maximum nutrient retention should be taught, especially when introducing new crops in the diet (quinoa for instance). In fact, it was demonstrated that cooking method exposing for a long-time plant foods to important temperature or water can have importantly degrade nutrients, especially vitamins. Boiling, simmering or poaching can have effects on water-based vitamins and exacerbate losses, vitamin C being primarily affected. Nevertheless, the consumption of the liquids created during the procedure ensures the intake of the leached nutrients (Coe & Spiro, 2022). On another side, grilling and broiling lead to a loss in B vitamins and increase the contain of cancer-related substances. Stir-frying, while beneficial for the absorption of fat-soluble vitamins, increases the possibility of burning the cooking-oils used. To address this risk, it is recommended to use certain types of fats, such as coconut oil or ghee, which are readily available in Nepal. Finally, deep-frying for too long is not suggested due to the production of harmful aldehydes, while steaming is considered one of the healthiest methods of cooking, minimizing vitamin C loss (Wood, 2024).

In addition, this study noted that pregnant women lack nutrition-related knowledge, especially when experimenting nausea during the first months and facing food taboos and cultural beliefs. Nutritional guidance must be provided during pregnancy to help manage symptoms and ensure adequate nutrient intake and dietary diversity. More generally, advice should be offered and explained for all periods of pregnancy and lactation.

It is essential that most of the household's member take part in these nutritional campaigns, as food-related decisions are often taken by many and influenced by family dynamics. Thus, the in-law family should be considered to promote positive-health behaviours and to raise awareness on nutrition, particularly for pregnant and lactating women, in traditional households. As a matter of fact, the participants were often responsible for cooking, but rarely involved in the food expenditures or shopping, leading to several stakeholders influencing nutritional outcomes. However, it was noted that elderly people are less likely to understand the importance of nutritional awareness and the specific needs of pregnant and lactating women. But if their views cannot be

changed while continuing to make most of the decisions in the household, it is unlikely that raising awareness among the targeted population or the younger generations will enable sustainable change. In fact, emotionally, people are more likely to adhere beliefs sustained by familiars than to implement foreigners' advice. The latter would also involve a need to possibly rebel against households' rules, which could be difficult to achieve. It is, therefore, crucial to **break the generational cycle of behaviour** negatively impacting nutrition.

Furthermore, the reliance on white rice should be discussed and alternative sources of carbohydrates explained, which would permit a better consumption of nutrients. People tend to eat their side dishes, representing legumes, vegetables and animal products, after consuming their rice, increasing the possibility of not finishing the most nutritive part of their dishes. This eating habit aspect should also be addressed through nutritional schools or visual communications.

Addressing social resistance if present

The NACCFL project will be implemented in the Bardiya District, targeting many populations and especially Mukta-Kamaiya households by providing them significant importance. This could create a lack of understanding from other communities and thus social challenges to accept the implementation of certain activities of the project.

To minimize the risk of social resistance by other communities than the Mukta Kamaiyas, it would be beneficial to conduct small educational campaigns or group workshops prior any activity implementation or specific investments towards the freed labourers. These efforts would raise awareness about the current challenges faced by the Mukta Kamaiyas, such as their limited food security (results of the assessed Nutrient Intake Adequacy and Diet Diversity Quality) compared to other communities. Their difficulties in owning bigger lands and in managing it freely (for instance their impossibility to contract a loan based on the land the government has given them) could be discussed as well. During these campaigns, answering to potential misunderstandings from other communities is essential and could make them sufficiently recognized. Explaining the importance of equity in distributing funds among populations for the overall development of a municipality or district is also critical.

Secondly, as community engagement is key, identifying representatives from each community in the process could ensure inclusivity and it could enable direct discussions of each community's reality.

Additionally, due to potential challenges, like low participation to these campaigns or workshops, as well as time, resources or capacity constraints, having a designated Mukta-Kamaiya representative in each municipality of the Bardiya District could facilitate rapid sharing of information related to their conditions when questions arise among the population. Engaging community leaders could help in mitigating resistance and enhancing acceptance and credibility.

Lastly, during the implementation phase, monitoring and evaluating the impact of the funds is recommended. Reports on these impacts should be shared and explained to all the communities, maintaining transparency and trust throughout the project.

Additional recommendations

Related to Nutritional Field Schools, program implementation, and government policies, it would be beneficial to enhance self-perception associated with the adequacy of one's diet. This would help the targeted individuals understand their nutritional needs and work towards meeting them. Regular monitoring to assess their perception and provide insights on their consumption patterns is necessary to adjust and identify future programs.

Further studies could help analyse adequacy's diets and nutritional intakes by considering bio-accessibility and bioavailability of nutrients. They are impacted by various factors, such as the food matrix and dish preparation, the actual chemical form of the nutrient as directly found in the product, the presence of absorption inhibitors or enhancers (such as vitamin D enhances calcium absorption), among other components (Wood, 2005).

Mukta-Kamaiya households should have the right to manage their lands on their terms, potentially following professional advice to minimize the risk of falling into modern forms of illegal slavery. This could allow them to use their lands as collateral to demand bank loans, and thus permit them investments in other professional sectors.

Since women are often feeling pressurized to conform to their in-law's families and rules, the creation of discussion groups could be a precious option. Through this platform, various issues could be discussed and solutions provided by people who have eventually faced similar situations. These groups could also permit dialogues on nutritional needs and other practical tips. Possibly, such activities could empower young and vulnerable women by helping them feel supported and less isolated.

Finally, nutritional programs could focus on providing subsidies for more nutritious and less consumed foods, such as vegetables, dairy products, and fish. This initiative could also be developed through community mutual assistance or by improving the productivity of these products in the targeted areas.