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Sustainable Consumption and Production of Food Nexus with Environmental Security: Assessing the State of Food Security in Pakistan

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Abstract: This paper examines the current state of food security in Pakistan, focusing on the factors influencing the nation's ability to ensure a stable food supply. The analysis covers food production, distribution, accessibility, and stability, while also considering socioeconomic and environmental factors. The role of government regulations and international collaborations is explored in addressing food security challenges. Despite the critical importance of agricultural governance for sustainable food production and economic development, Pakistan's agricultural sector remains under prioritized, suffering from a lack of strategic vision and inconsistent government support. This neglect undermines efforts to achieve food security and stability. The study evaluates the alignment of Pakistan's National Food Security Policy (2018) with global, national, and provincial standards for sustainable agricultural management. A framework based on principles, criteria, and indicators (PCI) was developed, utilizing both quantitative and qualitative methodologies. Forty-three indicators, eleven criteria, and one guiding principle across four dimensions were identified. Thirteen governance tools were assessed using a ratio scale (0–5), with results presented in a policy coherence matrix. The coherence index score of 2.14 indicates significant misalignment among regulatory instruments, highlighting gaps in addressing climate change, low-income food access, service management, and institutional capacity. The study reveals that many food policies in Pakistan are outdated and inconsistent, requiring revision to address local challenges and align with emerging international obligations. The findings provide a comprehensive overview of the current food security landscape in Pakistan, offering insights for more informed decision-making to build a resilient and sustainable food system.

Keywords: sustainable consumption; food nexus; environmental security; food security

1. Introduction

Food security is the physical and financial accessibility of all people, at all times, to safe, nourishing, and sufficient food that satisfies dietary requirements and food preferences to achieve a healthy, active lifestyle. The Food and Agricultural Organization (FAO) of the United Nations (UN) defined food insecurity as the insufficient and irregular access to safe and nutritious food necessary for normal growth, development, and a healthy, active life (Bahn et al., 2021) (Mustafa et al., 2021) (Ngo et al., 2016). In simpler terms, individuals who cannot reach a daily calorie goal of 21,000 calories are classified as food insecure (Stany et al., 2021). Thus, a country that possess food security has an adequate food supply (per capita food availability) to meet its food needs (per capita food requirements) (Hao et al., 2022) (Odey et al., 2023) (Zhu & Begho, 2022). While, there is food insecurity when there is insufficient economic, social, or physical access to food. Food availability, accessibility and affordability are the three dimensions of food security of a region gradually followed by stability. These dimensions cannot be achieved without sustainable production and consumption (SDG-12) of food.

On the other hand, a UN research claims that there is enough food produced to feed 10 billion people worldwide (Alfieri et al., 2023) (Fanzo & Miachon, 2023). The estimation of the world's population at 8 billion people shows that food production is very effective (Bahar et al., 2020) (Sakschewski et al., 2014). Since global vegetation productivity has increased over the past 20 years

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despite rising air temperatures and is now higher than human population levels, there is a very high rate of unsustainable food production and consumption, and around 30–40% of all food produced worldwide is wasted, even if there is enough food produced to serve 8 billion people, 800 million people still go without food (Domingo et al., 2023). Even more astonishing is the fact that the people all over the world are rely heavily on only 30 of them to supply people with the calories and nutrition they require on a daily basis. Three staple crops, rice, wheat, and maize, provide over 40% of the world's calories, or more of our daily calories (James et al., 2023). Food prices are impacted by a variety of factors, such as a supply and demand imbalance, extreme weather patterns, disease outbreaks, unsustainable production and consumption habits, food waste, wars, and natural disasters. Food is shipped across long distances, and the cost of shipping is increased by high oil prices. Because oil byproducts are important components of fertilizers, the price of oil has an impact on agriculture as well (Liobikienė et al., 2023).

Despite the two main external threats to the global food system the conflict in Ukraine and climate change there is a third major danger: the "food system" itself (Posel & Casale, 2021). The primary cause of periodic global food crises is the lack of political incentives to shift towards more just and environmentally friendly production. Food distribution has been found to be more significant than food production when looking at a global food system. The globe was not on schedule to make significant progress towards ending hunger and malnutrition in all of its forms by 2030 even before the pandemic COVID-19. Up to 61 million additional people are at risk of famine because to the COVID-19 pandemic, which will affect more people in 2022 than it did in 2020 and 2021. According to recent statistics, there were 720 million hungry people in 2019, 811 million in 2020, and 830 million in 2021, and the number is still rising. Due to the long-lasting impacts of the COVID-19 epidemic and the Russia-Ukraine war on global food security, 660 million people may still be hungry in 2030 (Hassan et al., 2023).

Analyzing food consumption statistics from2009 and 2016 reveals that food demand is increasing all across the world and predicted to increase from 59% to 98% by 2050 necessitating an increase in world food production (Moallemi et al., 2022) (Gupta et al., 2023). Meanwhile, food is wasted throughout the world, and under nutrition still exists in underdeveloped nations (Tambo et al., 2023). However, increase in demand is more pronounced for dairy and meat goods, depicting changing dietary habits. The management of livestock production and the use of sources of animal feed heavily influence global food security and the sustainability of food production and consumption. The maintenance of the livestock production system consumes a significant portion of the world's essential resources. Animal health is the most important factor in livestock production because it immediately reflects the financial effects of production losses that are related to the accessibility and availability of food (Datta et al., 2024).

Summarizing the debate, a nutritious diet is out of reach for almost 3 billion people. Nutrition, food security and the restructuring of the food system are currently of more importance (Uyanga et al., 2024). Natural forces like conflict, climate change, and economic slowdowns and downturns are having a negative impact on food security and nutrition (Gupta et al., 2023). The food system can better provide sustainable, affordable, and healthful meals when food system transformation focuses on robust infrastructure to these climate changes or drivers. There is an urgent need for global change adaptation techniques and policies, including methods for regulating water distribution, land use, commerce, post-harvest food processing, food prices, and food safety (Polman et al., 2023).

Food Security in Pakistan: A Situational Analysis

According to several studies, over half of Pakistan's population experiences food insecurity, while the country's per capita dietary energy supply exceeds its per capita dietary energy consumption (Rizwanullah et al., 2023). Hence, Pakistan is ranked 99th in terms of food security out of 129 nations according to the 2022 Global Hunger Index, Pakistan's score dropped to 26.1 compared to its rating in the previous 2014 edition, indicating that food insecurity is a severe issue in Pakistan (Abdullah et al., 2019). With respect to overall food security, according to National Nutrition Survey (2019), 36.2% (40–60 million) people are facing food insecurity and 20% are undernourished in Pakistan (Ullah & Badshah, 2023). In Pakistan, a staggering 90.7 million people fall short of the daily calorie intake of 21,000 calories. According to UN Program, World Food Program (WFP), 45% of

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children are stunted while according to UNICEF, 38% of children under five in Pakistan experience stunting, marking a concerning rise in this issue within the country, which now holds one of the highest rates globally (Aziz et al., 2021). With respect to regional distribution of Pakistan's food security situation, Baluchistan is at worst where 48% of the people are food insecure while over 40% of the people are also food insecure in Sindh (Azeem et al., 2016) (Rizwanullah et al., 2023). The situation is particularly critical in Sindh, where nearly 50% of children are affected, and the problem is escalating rapidly (Shahzad et al., 2023).

On the consumption side, Pakistan's population is expanding rapidly, so is food requirements. However, a large amount of food becomes waste before reaching to consumers either in agricultural fields or during storage and transportation (Shah & Khan, 2023). Global market dynamics, health challenges, low agricultural knowledge, limited agricultural diversification, social inequalities, lack of storage facilities, poor transportation infrastructure, poverty, unemployment, income inequality, extreme temperatures and policy failures are the main targets to overcome to achieve short, medium and long-term objectives of food security highlighted in NAP of Pakistan.

Pakistan grapples with food insecurity due to factors such as inadequate agricultural productivity, unpredictable political regimes, and corruption (Hussain & Routray, 2012) (Kalair et al., 2019). The poverty rate in Pakistan surged to 39.4% during the latest fiscal year, leading to an increase of 12.5 million individuals falling into poverty due to severe economic conditions (Howard, 2022). A staggering 95 million people in Pakistan find themselves living in poverty. Food price rises due to increase in imports and effects foreign exchange reserves of the country, due to which the country's currency is declining and import is becoming more expensive (Allouche, 2011) (Hussain & Routray, 2012).

Table 1. staple food production from 2018–2024.

Crops	Production (2018–2022)	Production (22–23)	Production (23–24)	%age Change (23–24)
Wheat	25,707	26,400	28,000	9
Rice	7530	5500	9000	20
Cotton	5640	3900	6700	19
Barely	48	42	55	14
Sunflower seeds	121	148	135	12

Source: International Production Assessment Division (IPAD).

Despite the overall increase in food production, the country's poorest and most vulnerable citizens face challenges in affording a nutritious diet. In specific areas of Pakistan, persistent poverty, frequent natural disasters, and precarious political and economic conditions contribute to widespread undernourishment and food insecurity (Economics, 2021) (Rafique & Rehman, 2017). The prevailing development patterns in the nation are unsustainable and must undergo a significant shift. To mainstream SCP in integral parts of the Sustainable Development Goals (SDG) objectives, a paradigm shift is necessary. Engaging stakeholders and establishing a policy framework are crucial elements (Rizwanullah et al., 2023).

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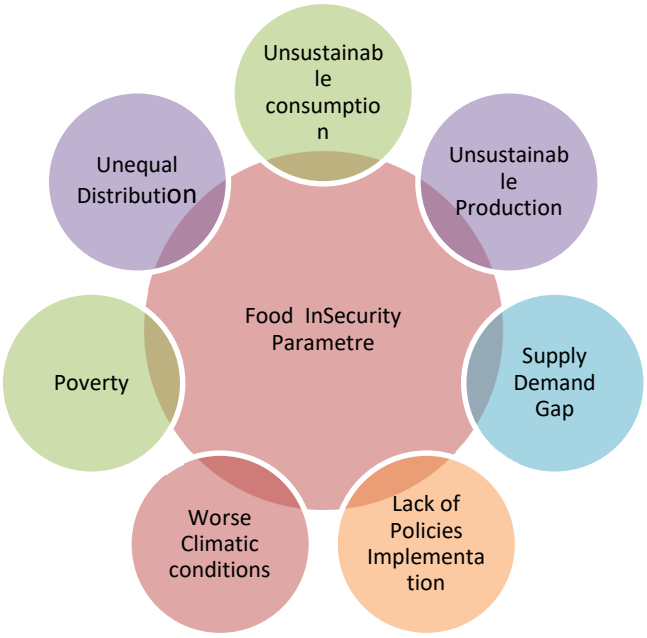

Figure 1. shows the factors affecting the food security.

Figure 3 shows the main causes of food insecurity in Pakistan. These factors are concluded from extensive literature study and In House Discussion (IHD) with the experts. Pakistan faces significant challenges in providing an adequate supply of nutritious food for its population, with concerns stemming from factors such as an aging demographic, shifting weather patterns, water scarcity, and insufficient infrastructure. As a result, ensuring food security remains a pressing issue. Pakistan encounters numerous challenges in achieving food security.

2. Methodological Framework

Millions of Pakistanis continue to grapple with the pressing and intricate challenge of food insecurity. Despite the nation's agricultural potential, a myriad of issues, encompassing population expansion, water scarcity, suboptimal farming practices, and economic disparity, compound this predicament. The far-reaching ramifications of food insecurity encompass not only hunger and malnutrition but also exert adverse influences on overall health, education, and economic productivity. Comprehensive domestic measures and international collaboration are essential to enhance food security in Pakistan. Addressing food insecurity is crucial, as it directly impacts the quality of life for individuals and plays a pivotal role in determining the future stability and prosperity of the country.

2.1. Study Approach

The complexities of food security require a multifaceted governance approach. The study involved a principle, parameters and objectives (PCI) framework to develop food security indices for analysis of relevant official instruments by covering the national and provincial integrating SDG-12 requirements. To meet the objective and scope of the study for food security objectives analysis, one (01) guiding principles i.e., End hunger, achieve food security and improved nutrition and promote sustainable agriculture was developed along with four (04) dimensions i.e., physical availability of food, economic and physical access to food, food utilization and stability, eleven (11) criteria's i.e., Social, economic, physical access, economic access, provision of services, socio-culture choices, policies and governance, institutional, coherence and coordination, and implementation and monitoring and forty-three (43) indicators were formulated to access the current state of food security in the country. Each of the selected objectives was analyzed based on the PCI framework (Aslam et al., 2023).

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2.2. Methodological Approach

This study has employed the blend of qualitative and quantitative tools and methods for data collection and analysis. These indicators were then sub-grouped into environmental, social and economic parameters to provide linkage of food security with environmental security. Secondly, it scrutinized the relevant national, provincial and federal regulatory frameworks in the food sector, employing a principle coherence analysis model. Food sector specific SMART scoring-based analysis matrix was developed through In-house Discussion (IHD) session with experts (Polman et al., 2023). Based on SMART score, coherence of food security and its implications across national and provincial commitments was analyzed and findings/conclusion have been drawn (Aslam et al., 2023).

The various steps involved during the course of the study are illustrated in methodological flow diagram in the Figure 1.

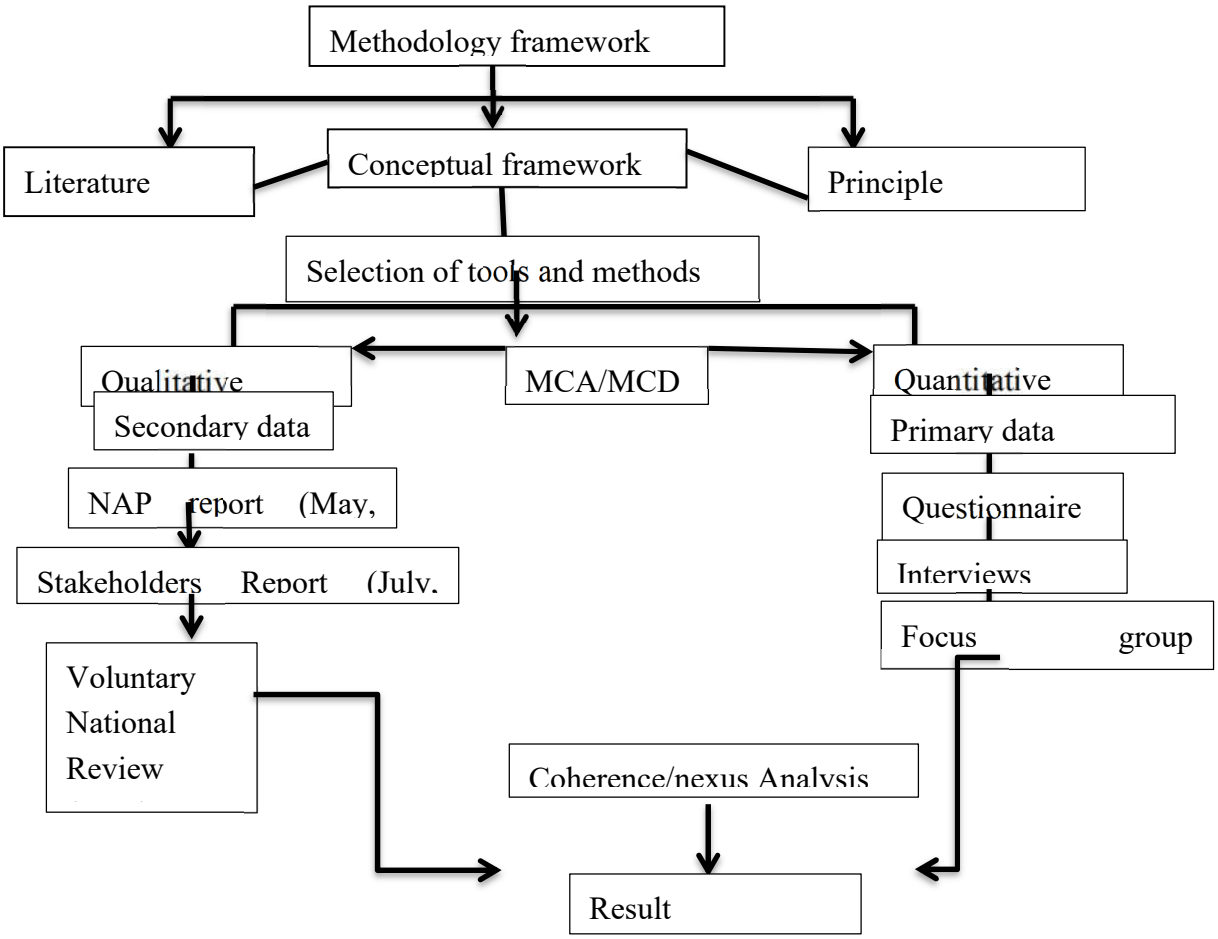

Figure 2. Methodological Framework.

For primary data eleven (11) criteria's environmental, social, economic, physical access, economic access, provision of services, socio-culture choices, policies and governance, institutional, coherence and coordination, and implementation and monitoring have been selected against the one guiding principle i.e., end hunger, achieve food security and improved nutrition and promote sustainable agriculture and incorporated into forty-three selected indicators for food security. The primary data was collected from the interviews and questionnaire and was further analyzed and scored on the bases of analysis (Aslam et al., 2023). The secondary data for this study's scope was gathered from literature studies, official documents, and yearly reports of the relevant departments, such as Pakistan Agriculture Research Council (PARC), National Agriculture Research Council (NARC), Provincial Irrigation Depts.', and Provincial Agriculture Extension, Ministry of National Food Security& Research, Provincial Agricultural Departments, Federal &Provincial Research

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Institutions, Academia and Livestock Departments. The academic and practical papers, reports, and statistics pertaining to Pakistan's food system have been evaluated in order to conduct the state of food security analysis and was then determined utilizing the paperwork that was already in existence and with the assistance of professionals and experts (Aslam et al., 2023).

2.3. Development of PCI Based Framework

For this purpose, a principle of food security along with four dimensions and eleven criteria were selected as objective for food security. For each criterion a set of indicators were formulated according to the food security objectives highlighted in National Action plan (NAP) of Pakistan (2017) National Food Security Policy (2018) &Pakistan Country Strategic Plan (2023–2027), through focus group discussions with experts. Focus group discussions were held in-house at International Islamic University Islamabad involving national and provincial stakeholders as well (Aslam et al., 2023).

2.4. PCI Framework Coding System

To streamline data management and distinguish between different sets, specific PCI codes were established.

(1) The coherence principle is denoted by the alphanumeric designation PC-N, where "PC" signifies the Principle of Coherence, and "N" represents the number of dimensions assigned to the principle, spanning from 1 to 4.
(2) Criteria selected against the Principle of Coherence with dimension one (PC-1A) are categorized as CN-EN^{e}. In this designation, C represents criteria, N denotes the serial number of the criterion, E signifies the PC-1A criteria category, and N ^{e} indicates the serial number within the PC-1A criteria category.
(3) Criteria selected against the Principle of Coherence with dimension 2 (PC-1B) are designated as CN-SNs. In this coding system, C represents criteria, N denotes the criterion's serial number, S signifies the PC-1B criteria category, and Ns indicate the serial number associated with the PC-1B criteria category.
(4) Criteria selected against the Principle of Coherence with dimension 3 (PC-1C) are documented as CN-GNg, where C denotes criteria, N represents the serial number of the criterion, G stands for the PC-1B criteria category, and Ng signifies the serial number within the PC-1C criteria category
(5) Criteria selected against the Principle of Coherence with dimension 4 (PC-1D) are documented as CN-PSs, where C denotes criteria, N represents the serial number of the criterion, P stands for the PC-1D criteria category, and Ss' signifies the serial number within the PC-1D criteria category
(6) Indicators corresponding to criteria selected against the Principle of Coherence, dimension 1 (PC-1) are designated as CN- EN^{e}Y. Here, C represents criteria, N denotes the serial number of the criterion, E signifies the PC-1 criteria category, Ne stands for the serial number within the PC-1A criteria category, and Y represents the indicator's serial number.

2.5. PC-1A's Parameters, Indicators, and Scope

'Food Availability' was selected as first dimension of coherence for Principle of food security (PC-1A) for Food Security Analysis (FSA), which revolves around the practice of producing and consuming food in a sustainable way and preventing detrimental changes to ecosystems and their constituent part. Pakistan has been grappling with a food availability crisis marked by multifaceted challenges that pose significant threats to its population. One of the primary concerns is the impact of climate change, which has led to erratic weather patterns, including unpredictable rainfall and extreme temperatures. The country's growing population adds another layer of complexity, placing immense pressure on the already strained food resources. Socioeconomic factors such as poverty, unequal distribution of wealth, and inadequate infrastructure contribute to the challenge, making it difficult for vulnerable populations to access nutritious food. Political instability and governance issues further impede effective policy implementation and exacerbate the food crisis. Addressing these interconnected issues demands a comprehensive approach that combines sustainable agricultural practices, water management reforms, poverty alleviation initiatives, and effective

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governance to ensure food security for the people of Pakistan. Fourteen indicators were formulated based on PC-1A and the three specified criteria for the analysis, as defined within the study's scope.

2.6. Criterion 1 of PC-1A: Physical Availability of Food: (C1-E1, C2-E2 & C3-E3)

Ensuring sufficient nutrition for every individual in Pakistan is a paramount goal that requires a multifaceted approach. Addressing this challenge involves a combination of government initiatives, community engagement, and educational programs. The food industry not only grapples with a crisis but also contributes to environmental uncertainties and disruptions in interconnected sectors. Hence, beyond tackling the food crisis, policies on food security should encompass ensuring the sustainable presence of food, considering social, economic, and environmental stability. Additionally, efforts should be directed towards strengthening institutional capacity at both national and subnational levels.

In this context, Pakistan's National Action Plan (NAP) comprehensively tackles various challenges related to food, including shortages, the adverse effects of climate change, inadequate infrastructure, imbalances in supply and demand, and unsustainable consumption and production patterns. The chosen metrics reflect Pakistan's dedication to addressing these issues through a commitment to both national and provincial governance.

Table 2. Multiple indicators for the criterion 1.

Code	Indicators (Environmental)	Scope-Wise Keywords
C1-E1.1	Measures exist to improve arable land for cultivation of food	Improving soil quality, prime agricultural lands.
C1. E1.2	Measures exist to improve agricultural yields sustainably	Better irrigation, hybrid varieties, resistant varieties, farm input.
C1. E1.3	Measures to assess climate vulnerability and adaptation exist to improve food availability in extreme events	Research &development, funds, stakeholders& IPPPs.
C1. E1.4	Measures to mitigate climate risk to food crops	imports, storage, food distribution
C1. E1.5	Measures to incentivize farmers for food crop diversification	subsidies, improved seeds quality
Code	**Indicators (Social)**	**Scope-Wise Keywords**
C2. E2.6	Measures to control food supply and demand imbalances due to demographic factors.	Food Stamp, Food Safety Net, income Support, Minimum Wage Programs.
C2. E2.7	Measures to ensure equitable distribution of food among provinces	Sustainable transport, disaster risk measures.
C2. E2.8	Measures exist to ensure availability of food for people living below poverty line	Emergency response Mechanisms.
C2. E2.9	Measures exist to meet essential nutrition requirement for pregnant women and infants	Caloric provisions, incentives.
C2. E2.10	Measures to control factors that imbalance food supply and demand e.g., immigration, urbanization	Consumption and production ratio, equal distribution, water availability.
Code	**Indicators (Economic)**	**Scope-wise Keywords**
C3. E3.11	Investment in agriculture sector	Stakeholders, IPPPs, incentives.
C3. E3.12	Identifying and fulfilling the needs of the small land holders to improve crop productivity	subsidies, incentives, markup free loans

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C3. E3.13	Measures to reduce expenditure on food imports	improved agricultural practices, machineries, on farm water management
C3. E3.14	Provision of economic subsidies, incentives, technological access to farmers	improved agricultural products

2.7. Criterion 2 of PC-1B: Economic and Physical Access to Food: (C4-S1 & C5-S2).Seven Indicators were Formulated Based on PC-1B and Two Specified Criteria for the Analysis, as Defined Within the Study's Scope

Food security remains a pressing global concern, with significant challenges arising from both economic and physical barriers to access. Economically, rising food prices, income inequality, and economic downturns exacerbate the vulnerability of marginalized populations. Many individuals and families find themselves unable to afford an adequate and nutritious diet, leading to malnutrition and other health issues (Tortajada & González-Gómez, 2022). Moreover, limited physical access to food, especially in remote or conflict-affected areas, poses a formidable obstacle. As a result, vulnerable communities face difficulties in obtaining sufficient food, perpetuating a cycle of hunger and poverty. Addressing these interconnected issues requires comprehensive strategies that encompass economic empowerment, social safety nets, improved infrastructure, and targeted interventions to ensure equitable access to food for all (Rahman et al., 2024).

Table 3. Multiple indicators for the criterion 2.

Code	Indicators (Physical Access)	Scope-Wise Keywords
C4-S1.1	Mechanisms to provide and improve access to food markets	storage facilities, improved transportation structure, fuel prices, economical safe
C4. S1.2	Mechanism is in place to ensure access to food in vulnerable situations e.g., famine, floods, droughts	Disaster management.
C4. S1.3	Governance and institutional framework exist to cater seasonal variation in food diversity	climate change adaptations and mitigation measures
C4. S1.4	Measures to promote subsistence farming, kitchen gardening, livestock keeping	climate resilient adaptations
Code	**Indicators (Economic Access)**	**Scope-Wise Keywords**
C5. S2.5	Measures to improve per capita GDP (Purchasing Power)	Affordability of nutritious diet.
C5. S2.6	Measures to control food inflation (cost of food)/food price index	policies, export import ratio, crop production within the border
C5. S2.7	Measures to improve minimum wage/reduce proportion of people below poverty line	Policies, laws, subsidies, incentives.

2.8. Criterion 3 of PC-1C: Food Utilization: (C6-G1 &C7-G2).Nine Indicators were Formulated Based on PC-1C and Two Specified Criteria for the Analysis, as Defined Within the Study's Scope

Pakistan faces several challenges in ensuring food security, with issues in food utilization playing a crucial role in exacerbating the problem. One major concern is the lack of proper storage and transportation infrastructure, leading to significant post-harvest losses. Inefficient supply chains and inadequate cold storage facilities contribute to the spoilage of perishable goods, diminishing the overall quantity and quality of available food. The prevalence of traditional, often rich and calorie-dense, dishes can contribute to health concerns such as obesity and related diseases. Additionally, gender roles and societal norms may influence food choices, with women often burdened by traditional expectations related to meal preparation. Furthermore, globalization and urbanization

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bring the infiltration of fast food and processed products, posing challenges to the preservation of local culinary heritage and the health of the population. Addressing these problems requires a balanced approach that acknowledges and respects cultural diversity, promotes nutritional education, and strives for equitable access to a range of healthy food options. Addressing these challenges requires a comprehensive approach that includes investments in infrastructure, education, and health services to improve food utilization and enhance overall food security in Pakistan (Mustafa et al., 2021).

Table 4. Multiple indicators for the criterion 3.

Code	Indicators (Provision of services)	Scope-Wise Keywords
C6-G1.1	Provision for safe drinking water and sanitation facilities	Improved health conditions.
C6. G1.2	Measures to control wasting, stunting and obesity in young children and adults	Policies, eco-labeling, eco-friendly, nutritious.
C6. G1.3	Measures to improve maternal health and birth weight	policies, free follow-ups, provision of healthy food, minerals, vitamins
C6. G1.4	measures to control Anemia among women of reproductive ages	Health policies, free nutritional food provision.
C6. G1.5	Measures to promote exclusive breastfeeding among infants	Awareness programs, campaigns, health care of mothers.
Code	**Indicators (Socio-cultural choices))**	**Scope-Wise Keywords**
C7-G2.6	Measures to address lack of awareness regarding nutritional needs	awareness programs, campaigns
C7-G2.7	Measures to improve cooking and food habits	appropriate nutritional food
C7-G2.8	Diversification in food choices by consumers for example dairy consumption	caloric provisions, incentives
C7-G2.9	Promoting indigenous food items instead of importing	improved production, variety of crops

2.9. Criterion 4 of PC-1D: Stability: (C8-P1, C9-P2, C10-P3 & C11-P4)

Thirteen indicators were formulated based on PC-1D and four specified criteria for the analysis, as defined within the study's scope.

Pakistan faces significant challenges in achieving food stability due to various issues related to policies, governance, institutional, and coherence weaknesses. One of the primary problems lies in the inadequacy of policies and their implementation. Coherence among different sectors is essential for a holistic approach to food security, but the absence of integrated strategies and collaboration between government departments' results in fragmented efforts. To address these challenges, Pakistan needs to focus on developing and implementing robust policies, improving governance structures, strengthening institutions, and fostering better coordination among various stakeholders to ensure a more stable and secure food supply for its population (Britwum & Demont, 2022).

3. Results and Discussion

3.1. Broad-Spectrum of the Research

In the context of this study, which investigated the alignment of food security within sectoral governance frameworks concerning the food security principle i.e., end hunger, achieve food security and improved nutrition and promote sustainable agriculture, this section reveals and deliberates upon the discovered results. To facilitate the analysis of coherence and sustainability, the study employed a framework based on principle, criteria, and indicators (PCI). The examination of the

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national food security status and sectoral governance within the food sector involved the application of one principle, eleven criteria, and forty-three indicators, all within the framework of sustainable development, at the national, provincial, and federal levels.

Results are presented in Section 4.2, where sub-sections 4.2.1 classify governing instruments, 4.2.2 display the overall coherence index of the Food Security Assessment (FSA), 4.2.3 demonstrate the principle-wise coherence index, 4.2.4 illustrate the criteria-wise coherence index, 4.2.5 show the FSA's coherence with direct governing instruments, and 4.2.6 reveal the FSA's coherence with indirect governing instruments. Building on these findings, Section 4.3 engages in a discussion of the results of the research.

3.2. Results and Findings

Establishing Framework for Governance Instruments

Table 4.1 illustrates the outcomes of the process of shortlisting and categorizing governing instruments based on their inherent characteristics (constituent, regulatory, or distributive) and their level of connection, whether direct or indirect, to the principles of food security. A comprehensive review of 13 governing instrument was conducted in terms of coherence with food availability, accessibility and affordability.

(1) ***The Pure Food Ordinance, 1960:*** The 1960 Pure Food Ordinance revises and consolidates regulations related to the production and sale of food. With minor adjustments, all provinces and specific northern territories have endorsed this legislation. Its primary goal is to safeguard the purity of market-sold food by preventing adulteration. Individuals are legally prohibited from mixing, coloring, staining, or powdering food in violation of approved regulations or if they anticipate that such actions may compromise the healthiness of the food (Ashraf et al., 2023).

(2) ***Pakistan Pure Food Laws (PFL), 1963:*** The existing legal framework for food quality and safety in the country is structured around the PFL. Additionally, it incorporates milk and its derivatives. These regulations specifically cover aspects such as heavy metals, antioxidants, synthetic colors, preservatives, and raw food additives (Drew & Crase, 2023).

(3) ***The Cantonment Pure Food Act, 1966:*** The Pure Food Act of 1960 and the Cantonment Pure Food Act of 1966 exhibit minimal distinctions between them, with closely aligned operational guidelines.

(4) ***Pakistan Hotels and Restaurant Act, 1976:*** The Pakistan Hotels and Restaurants Act of 1976 oversee all hotels and dining establishments in the country, aiming to manage and enforce standards for service and pricing. Section 22(2) of the act prohibits the sale of contaminated food or beverages that were not prepared in a hygienic manner or served with dirty or unclean utensils.

(5) ***The Pakistan Standards and Quality Control Authority (PSQCA) Act, 1996:*** This legislation prioritizes the maintenance of testing laboratories' standards by aligning practices and equipment with updated regulations and technological progress. It also involves conducting training sessions for the public and stakeholders, monitoring the production lines of diverse food products, and ensuring compliance with industry hygiene standards (PFA, 2018) (Farrukh et al., 2022).

(6) ***Punjab Food Pure Regulations, 2018:*** Deals with food quality, equal distribution pattern, no preservatives, additives should be added, packaging and food storage facilities should not be compromised.

(7) ***Pakistan Food Security Policy, 2018:*** *To* ensure a state-of-the-art and efficient food production and distribution system that, in terms of availability, accessibility, utilization, and stability, can most effectively bolster food security and nutrition (Khalid Bashir, 2017).

3.3. Overall Coherence Index of FSA

Concerning all levels of governance and governing instruments, whether they are constituent, regulatory, or distributive in nature, and their direct or indirect connection with the shipping sector,

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Table 4.2 provides an index measuring the overall coherence of the Food Security Act (FSA) within the sectoral governance framework for food stability in Pakistan. The average index score across all outcomes is 2.14. The scores based on specific criteria are as follows: The average coherence score for C1–E1 is 2.20, for C2–E2 is 2.49, and for C3–E3 is 1.89. Additionally, the average score for C4-S1 is 2.65, for C5-S2 is 1.11, for C6–G1 is 2.56, for C7–G2 is 2.05, for C8–P1 is 2.04, for C9–P2 is 2.55, for C10–P3 is 2.38, and for C11–P4 is 2.32. These results illustrate both the overall coherence and the score range based on criteria, indicating partial to poor coherence. The criterion related to economic access, denoted as C5-S2, and received the lowest rating among the eleven criteria.

Economic access plays a pivotal role in exacerbating food insecurity in Pakistan, emerging as a primary threat to the nation's ability to ensure a reliable and nutritious food supply for its population. The country faces numerous challenges, including high levels of poverty, unemployment, and income inequality, which collectively hinder the ability of a significant portion of the population to afford an adequate and diverse diet. Addressing economic disparities and enhancing income-generating opportunities are crucial steps in ensuring sustainable and widespread food security in Pakistan.

Table 5. Criteria-wise average score.

Criteria Code	Criteria	Coherence Index	Level of Coherence
C1-E1	**Environmental (C1-E1)**	**2.20**	Partial
C2-E2	**Social (C2-E2)**	**2.49**	Partial
C3-E3	**Economic (C3-E3)**	**1.89**	Limited or Poor
	Total Average	**2.19**	**Partial**

3.3.1. Principle Dimension (PC-1B)

Second principle dimension comprises two key elements, namely economic access (C4-S1) and physical access (C5-S2), each accompanied by six corresponding indicators. The overall average coherence index of a selected principle along with dimension 2 was determined to be (3.76). As illustrated in Table 4.4, C4-S1 obtained an average index score of 2.65, slightly surpassing that of C5-S2. The findings indicate that within the realm of criterion-1, indicator C4-S1 2.65, encompassing both financial and physical access to food, secured the highest coherence score (2.65). This indicator addresses aspects such as food storage facilities, sustainable transportation systems, subsidies for sustainable transportation, and sustainable practices in food production and consumption. On the other hand, indicator C5-S2.1, focusing on the affordability of a nutritious diet, food inflation, the food price index, as well as relevant regulations, legislation, subsidies, and incentives, exhibited the lowest coherence scores (1.11).

Table 6. Criteria-wise average score.

Criteria Code	Criteria	Coherence Index	Level of Coherence
C4-S1	**Physical Access (C4-S1)**	**2.65**	Partial
C5-S2	**Economic Access (C5-S2)**	**1.11**	Poor or limited
	Total Average	**1.88**	**Poor or limited**

3.3.2. Principle Dimension (PC-1C)

Coherence of third principle dimension with the selected principle comprises two components: socio-cultural choices (C6-G1) and service provision (C7-G2), each with its set of nine indicators. While policy documents recognized the overall findings as "partially coherent," the average index score for C6-G1 was higher than that for C7-G2 (see Table 4.5). The overall coherence score for dimension 3 was 2.30.

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Table 7. Criteria-wise average score.

Criteria Code	Criteria	Coherence Index	Level of Coherence
(C6-G1)	**Socio-cultural choices (C6-G1)**	**2.56**	Partial
(C7-G2)	**Provision of services (C7-G2)**	**2.05**	Partial
	Total Average	**2.30**	**Partial**

3.3.3. Principle Dimension (PC-1D)

The fourth principle dimension comprises four components: Policies & Governance (C8-P1), Institutional (C9-P2), Coherence & Coordination (C10-P3) and Implementation & Monitoring (C11-P4), each with its set of thirteen indicators. While policy documents recognized the overall findings as "partially coherent," the average index score for C10-P3 was higher than that for C8-P1, C9-P2 and C11-P4 (see Table 4.5). The overall coherence score of dimension 4 for a selected food stability principle was 2.24.

Table 8. Criteria-wise average score.

Criteria Code	Criteria	Coherence Index	Level of Coherence
(C8-P1)	**Policies & Governance(C8-P1)**	**2.04**	Partial
(C9-P2)	**Institutional(C9-P2)**	**2.25**	Partial
(C10-P3)	**Coherence & Coordination(C10-P3)**	**2.38**	Partial
(C11-P4)	**Implementation & Monitoring (C11-P4)**	**2.32**	Partial
	Total Average	**2.24**	**Partial**

3.4. Index of Coherence Based on Criteria

The FSA's overall coherence index, with a total score of 2.15, is presented in Table 4.7. However, Table 4.2 highlights variations in criteria-specific scores. The governance framework records the lowest score (1.11), signifying a lack of attention to economic access and food affordability within the realm of food security. Similarly, efforts to enhance food accessibility across environmental, societal, and economic dimensions have proven inadequate. It is imperative to update the National Food Policy, specifically addressing the governance framework for food stability, taking into account national, provincial, and federal responsibilities.

The Pakistan Pure Food Laws (PFL) of 1963 stands out as a pivotal policy in the realm of food regulation. To effectively meet the food security objectives outlined in Sustainable Development Goal 2 (SDG 2), it is imperative that amendments be promptly made to the Pakistan Pure Food Laws (PFL), 1963, aligning them with the present requirements of the specified targets. This study inquires an exhaustive, covering a wide range of regulatory instruments (refer to Table 4.2), including national and provincial policies, plans, acts, and laws that have direct or indirect relevance to the food industry.

The PCI framework, which establishes standards and benchmarks for ensuring the stability of the food sector, serves as the foundational framework for this study. Consequently, the study employs eleven criteria (C11-P4), forty-three indicators, and four dimensions namely, the physical availability of food (PC-1A), economic and physical access to food (PC-1B), food utilization (PC-1C), and stability (PC-1D) to evaluate and address the security and sustainability aspects of the food sector. Moreover, to ensure vertical coherence, the study not only encompassed all four levels of governance but also considered cross-sectoral governance by selecting relevant governance instruments directly or indirectly impacting the food industry. Following extensive research and internal expert deliberations, the study identified 13 national governance instruments, comprising plans, rules, and policies. Among these, three documents directly pertain to the food security parameters, while the remaining documents address topics with indirect implications for food production and consumption. The classification of these governance instruments facilitated a clearer comprehension of connections and overlaps in the governance process.

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The results of the study, which pertain to both direct and indirect aspects of the food industry, reveal significant deficiencies in Pakistan's policies and regulatory frameworks concerning food security and sustainability. Furthermore, the overall quantitative coherence index score of 2.14 suggests inconsistency in the governance procedures of the food industry. In terms of the dimensions and indicators of food security, the Pure Food Ordinance Act of 1960, Pakistan Pure Food Laws (PFL) of 1963, the Cantonment Pure Food Act of 1966, and the Pakistan Hotels and Restaurant Act of 1976 exhibit notably low coherence indices of 1.04, 0.60, 0.73, and 0.08, respectively. With an overall coherence index of 2.19, the assessment of food availability (PC-1A) was based on three criteria: economic, social, and environmental factors, shedding light on significant gaps concerning the four primary sustainable development goals. Principle dimension 2, (PC-1B) encompassing both physical and financial access to food, obtained the lowest score at 1.88. Notably, the economic access indicator received the lowest score among all eleven indicators, ranging from 1.11 to 2.65, indicating poor performance across the board.

Food stability, a fourth dimension of a selected principle (PC-1D) deals with the four criteria Policies & Governance (C8-P1), Institutional (C9-P2), Coherence & Coordination (C10-P3) and Implementation & Monitoring(C11-P4) with the coherence indexes of 2.04, 2.25, 2.38 and 2.32 respectively. All these four criteria show the very week or partial coherence with the governing instruments. Pakistan faces significant challenges in ensuring food stability, with various issues stemming from deficiencies in policies and governance, institutional shortcomings, coherence and coordination lapses, and weaknesses in implementation and monitoring. On the policy and governance front, there is a need for comprehensive and effective strategies to address food security issues. The existing policies often lack the necessary depth and fail to adapt to evolving challenges. Institutional weaknesses further hinder progress, with inadequate structures and resources for managing food stability initiatives. Addressing these multifaceted challenges requires a holistic approach, involving policy reform, institutional strengthening, improved coordination, and enhanced monitoring and evaluation mechanisms.

4. Conclusions

Food security coherence with governing instruments often reveals notable gaps that hinder effective and inclusive policies. One significant challenge lies in the fragmented nature of food governance structures, both at national and international levels. The absence of a unified approach often results in disjointed efforts, leading to inefficiencies in addressing global food security issues. Additionally, disparities in resources and capacities among nations further exacerbate these gaps, as some countries struggle to implement and enforce comprehensive food policies. Inconsistencies in regulations, inadequate monitoring mechanisms, and limited collaboration between various stakeholders contribute to the persistence of food insecurity. Bridging these gaps requires a holistic and coordinated effort to align policies, enhance collaboration, and establish a more integrated approach to food governance, ensuring a sustainable and equitable food future for all (Kumari & Singh, 2023).

In Pakistan, the issue of food security looms large on the national agenda, given the multitude of challenges the nation grapples with in the realms of agriculture, climatic shifts, and economic progress. This paper delves into the imperative of food security concerning Pakistan's national integrity and delineates potential measures to ensure that every citizen enjoys unhindered access to adequate sustenance. This dilemma predominantly stems from Pakistan's heavy dependence on agriculture as a primary economic pursuit and the adverse impacts of climate change on agricultural yields. Malnutrition can also weaken the immune system, increasing susceptibility to illnesses and raising healthcare expenses. Furthermore, food insecurity can give rise to societal unrest, political instability, and economic downturns. Hunger often drives individuals towards criminal behaviors or political radicalization (Abidi, 2023).

5. Recommendations

A concerted effort is necessary in Pakistan to combat food insecurity in both rural and urban areas. This effort requires collaboration among diverse stakeholders and sectors, with a focus on enhancing various aspects of the food supply chain, such as processing, transportation, storage,

production, and marketing. Accessibility to food markets for both consumers and producers needs to be improved. It is imperative to establish guidelines, legislation, and regulations to bolster seed quality control, consumer protection, and payment systems. Pakistan must upgrade the capabilities of livestock and agriculture producers through the adoption of modern technologies to ensure the practice of climate-smart agriculture.

The government of Pakistan should invest in research and development to increase food production yields. Offering credit facilities to farmers for the purchase of high-quality seeds, fuel for machinery, and transportation will help enhance agricultural productivity. Establishing a supply-demand cycle is essential for sustaining crop production and consumption. Measures to control smuggling and hoarding should be implemented by the relevant authorities. A comprehensive transformation of the food system is needed to ensure both food and environmental security (Babu & Gajanan, 2022). This can be achieved through the introduction of integrated farming systems, combining crop cultivation with livestock, poultry, and fish, thereby creating year-round employment and additional income. The promotion of culturally appropriate food choices, the introduction of systems like the Duck-Fish Pedi system, permaculture, and the adoption of rainwater and grey-water harvesting should be encouraged. Farmer-friendly policies should be implemented to support these initiatives (Babu & Gajanan, 2022).

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