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Carbon Footprint Of Traditional Indian Dishes: Evaluating The Environmental Impact Of Regional Diets

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Abstract

Traditional Indian food includes a wide range of meals from different parts of the country, diets, and ways of cooking them. The carbon footprint of 753 classic Indian dishes is examined in this extensive study to assess their environmental impact and find tren ds among dietary habits and regions. Using a Kaggle dataset that included comprehensive nutritional and carbon footprint data, we evaluated foods from three dietary categories (vegetarian, non-vegetarian, and eggetarian) and five geographical regions (North, South, East, West, and Continental). Our study shows notable disparities in environmental impact, with non-vegetarian dishes having a carbon footprint that is 2.38 times more than that of vegetarian substitutes (1.3413 vs. 0.5640 kg CO2e). According to regional data, South Indian cuisines have the lowest average impact (0.5726 kg CO2e), whereas Continental food has the most (0.7079 kg CO2e). The study offers vital information for creating sustainable dietary recommendations and encouraging ecologically friendly traditional Indian food selections.

Keywords: Carbon footprint, Traditional Indian cuisine, Environmental impact, Sustainable diet, regional cuisine, Food sustainability

1. Introduction

Dietary decisions are crucial to mitigate climate change because the global food system accounts for 25–30% of all greenhouse gas emissions (Poore & Nemecek, 2018). The difficulty for traditional cuisines, especially those with a rich cultural legacy, such as Indian cuisine, is to strike a balance between environmental sustainability and cultural preservation. India offers a unique chance to research the environmental effects of traditional food systems because of its many regional cuisines and traditional diet that is primarily plant-based.

The local climate, farming methods, and cultural preferences all have an impact on the regional variations in Indian food. With regional variances in the amount of dairy, meat, and seafood consumed, the traditional Indian diet has long been defined by a high percentage of plant- based foods. In order to preserve ethnic food traditions and inform sustainable dietary standards, it is imperative to comprehend the carbon footprint of these traditional recipes.

The goal of this study is to present a thorough evaluation of the carbon footprint of many traditional Indian cuisines, takin g into account regional, nutritional, and preparation-related variables. The results add to the expanding corpus of research on sustainable food systems and offer useful information to the food business, consumers, and legislators.

1.1 Research Objectives

1. Quantify the carbon footprint of traditional Indian dishes across different regions
2. Compare environmental impact across dietary categories (vegetarian, non-vegetarian, eggetarian)
3. Identify high and low carbon footprint dishes within traditional Indian cuisine
4. Analyze the relationship between food weight and carbon footprint
5. Provide recommendations for sustainable food choices within traditional Indian cuisine

1.2 Research Questions

- What is the average carbon footprint of traditional Indian dishes?
- How do carbon footprints vary across different regions of India?
- What is the environmental impact difference between vegetarian and non-vegetarian traditional dishes?
- Which traditional dishes have the highest and lowest environmental impact?
- What patterns exist in the relationship between dish characteristics and carbon footprint?

2. Literature Review

2.1 Food System Carbon Footprints

Emissions from agricultural production, processing, transportation, storage, and waste disposal are all part of the carbon footprint of food systems. Compared to plant-based diets, research shows that the production of livestock contributes disproportionately to greenhouse gas emissions (Gerber et al., 2013). Dietary changes toward plant-based meals are identified as a crucial mitigation approach in the IPCC Special Report on Climate Change and Land (IPCC, 2019).

2.2 Traditional Diets and Sustainability

The possible sustainability benefits of traditional food habits have drawn attention. According to research on traditional diets in Asia, the Nordics, and the Mediterranean, culturally based food systems frequently support the ideas of environmental sustainability (Dernini et al., 2017). However, there is only a limited amount of research exists specifically on the carbon footprint of Indian traditional cuisine at the dish level.

2.3 Regional Variations in Indian Cuisine

Because of regional variations in climate, agricultural systems, and cultural customs, Indian food is remarkably diverse. Southern food places more of an emphasis on rice, legumes, and vegetables, while Northern cuisine typically contains more dairy and meat products. These regional variations could result in different environmental effects (Shetty, 2002).

3. Methodology

3.1 Data Source and Dataset Description

This study utilizes a comprehensive dataset sourced from Kaggle containing detailed information on 753 traditional Indian dishes. The dataset includes:

- **Food items**: 753 unique traditional Indian dishes
- **Regional classification**: North, South, East, West, and Continental
- **Dietary categories**: Vegetarian (Veg), Non-vegetarian (Non-veg), and Eggetarian
- **Nutritional information**: Energy, proteins, carbohydrates, fats, fiber
- **Physical characteristics**: Serving size, total weight
- **Environmental impact**: Carbon footprint in kg CO2 equivalent
- **Ingredients**: Detailed ingredient lists for each dish

3.2 Data Analysis Approach

Statistical analysis was conducted using SPSS 27.

Descriptive statistics: Mean, median, standard deviation, and distribution analysis

1. **Comparative analysis**: Between dietary categories and regions using t-tests and ANOVA
2. **Effect size calculation**: Cohen's d to quantify practical significance
3. **Correlation analysis**: Relationship between dish characteristics and carbon footprint

3.3 Carbon Footprint Calculation

Carbon footprints were calculated as kg CO2 equivalent per serving, considering the complete lifecycle assessment of ingredients from production to preparation. The methodology accounts for:

- Agricultural production emissions
- Processing and manufacturing
- Transportation
- Storage and preparation
- Waste generation

4. Results

4.1 Overall Dataset Characteristics

The analysis of 753 traditional Indian dishes reveals the following overall characteristics:

- **Mean carbon footprint**: 0.6573 ± 0.6847 kg CO2e per serving
- **Median carbon footprint**: 0.4715 kg CO2e per serving
- **Range**: 0.0000 to 7.5990 kg CO2e per serving
- **Distribution**: Right-skewed with 18.5% of dishes exceeding 1.0 kg CO2e

4.2 Dietary Category Analysis

Significant differences exist across dietary categories ($p < 0.001$, Cohen's $d = 0.896$):

Vegetarian dishes (n=641, 85.1%)

- Mean: 0.5640 ± 0.5566 kg CO2e
- Median: 0.4198 kg CO2e
- Range: 0.0000 to 5.5625 kg CO2e

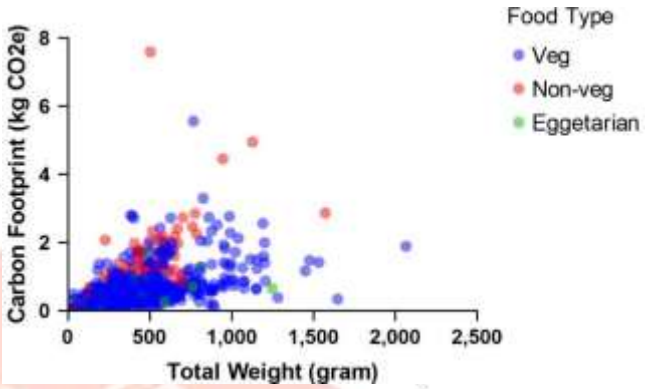
Non-vegetarian dishes (n=86, 11.4%)

- Mean: 1.3413 ± 1.1021 kg CO2e
- Median: 1.1384 kg CO2e
- Range: 0.0227 to 7.5990 kg CO2e

Eggetarian dishes (n=26, 3.5%)

- Mean: 0.6958 ± 0.4561 kg CO2e
- Median: 0.7192 kg CO2e
- Range: 0.0175 to 1.8167 kg CO2e

Non-vegetarian dishes exhibit 137.8% higher carbon footprint compared to vegetarian alternatives, representing a 2.38x multiplier effect.



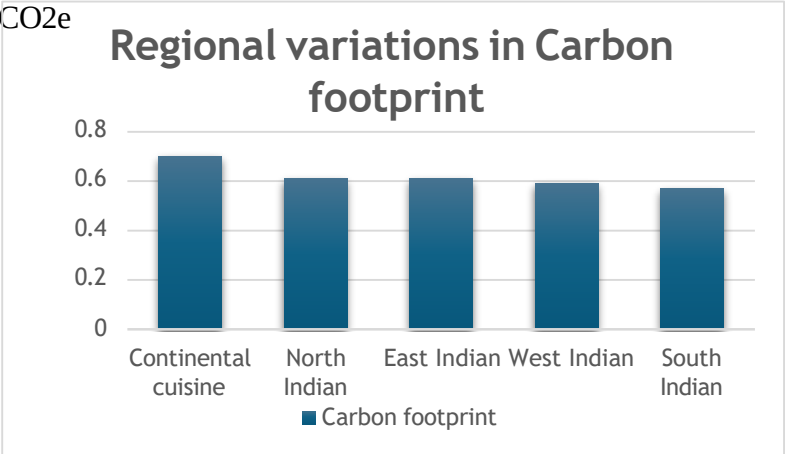
Graph1: Relationship between Food Weight and Carbon Footprint by Dietary Category

4.3 Regional Analysis

Regional variations in carbon footprint demonstrate distinct patterns:

Continental cuisine (n=310): 0.7079 ± 0.7380 kg CO2e **North Indian** (n=425): 0.6135 ± 0.6512 kg CO2e **East Indian** (n=402): 0.6111 ± 0.6204 kg CO2e **West Indian** (n=420): 0.5886 ± 0.6017 kg CO2e **South Indian** (n=243): 0.5726 ± 0.5978 kg CO2e

Continental cuisine shows the highest average carbon footprint, while South Indian cuisine demonstrates the most environmentally sustainable profile among traditional regional cuisines.



4.4 High-Impact Dishes

Analysis of the highest carbon footprint dishes reveals specific patterns:

Top 5 High-Carbon Dishes:

1. Non-vegetarian tacos: 7.5990 kg CO2e (Non-veg, Continental)
2. Cold Coffee: 5.5625 kg CO2e (Veg, Continental)
3. Chicken Tikka: 4.9525 kg CO2e (Non-veg, North)
4. Pyaazi Kebab: 4.4580 kg CO2e (Non-veg, North)
5. Paneer Vegetable Curry: 3.2985 kg CO2e (Veg, North)

Notably, 60% of the top 10 highest-impact dishes are from Continental cuisine, and 70% are non-vegetarian, indicating the compound effect of dietary choice and cuisine type.

4.5 Low-Impact Alternatives

The analysis identified numerous low-carbon alternatives:

- **Zero carbon footprint**: 5 dishes (0.7% of total)
- **Low impact (≤0.2 kg CO2e)**: 102 dishes (13.5% of total)
- **Below median**: 377 dishes (50% of total)

Examples of sustainable choices include traditional preparations like basic rice dishes, simple vegetable preparations, and traditional beverages using minimal processed ingredients.

4.6 Distribution Analysis

Carbon footprint distribution analysis reveals:

- **25th percentile**: 0.2116 kg CO2e
- **75th percentile**: 0.8155 kg CO2e
- **90th percentile**: 1.4311 kg CO2e
- **High-impact dishes (>1.0 kg CO2e)**: 139 dishes (18.5%)
- **Very high-impact (>2.0 kg CO2e)**: 33 dishes (4.4%)

The right-skewed distribution indicates that while most traditional dishes have moderate environmental impact, a small percentage contribute disproportionately to overall carbon footprint.

5. Discussion

5.1 Environmental Implications of Dietary Choices

According to international studies on the effects of animal-based diets on the environment, non-vegetarian dishes have a 2.38x larger carbon footprint than vegetarian equivalents. This conclusion has important ramifications for both individual food choices and environmental policy, especially in a nation where vegetarianism is deeply ingrained in the culture.

With their focus on plant-based meals, traditional Indian dietary patterns appear to offer intrinsic sustainability benefits, as seen by the significant difference between vegetarian and non-vegetarian cuisines. However, the existence of high-impact vegetarian foods (such as some preparations that are high

in dairy) shows that sustainability cannot be presumed based only on the lack of meat.

5.2 Regional Variations and Cultural Implications

The regional analysis reveals interesting patterns that reflect local agricultural systems and cultural preferences. South Indian cuisine's lower average carbon footprint may be attributed to:

- Higher proportion of rice-based dishes with lower processing requirements
- Traditional use of local, seasonal vegetables
- Less reliance on dairy-intensive preparations
- Traditional cooking methods that

minimize energy use Continental cuisine's higher impact likely reflects:

- Greater use of processed ingredients
- Higher proportions of animal-based products
- More energy-intensive preparation methods
- Dishes adapted from global cuisines with different sustainability profiles

5.3 Implications for Sustainable Food Systems

The vast range of carbon footprints (0.0000 to 7.5990 kg CO2e) found in traditional Indian food shows that making educated food choices can have a major positive impact on the environment without sacrificing local culinary customs. This finding is especially significant to consumer education initiatives and policy responses.

5.4 Limitations and Future Research

1. **Ingredient sourcing**: The analysis assumes average production methods and may not reflect regional variations in agricultural practices
2. **Preparation methods**: Different cooking techniques and fuel sources may affect carbon footprint calculations
3. **Seasonal variations**: The impact of seasonal availability and preservation methods is not fully captured
4. **Cultural context**: The dataset may not represent the full diversity of traditional preparation methods

Future research should investigate:

- Regional variations in ingredient production systems
- Impact of traditional vs. modern cooking methods
- Seasonal variations in dish carbon footprint
- Consumer acceptance of sustainable traditional food choices

6. Recommendations

6.1 For Consumers

1. **Prioritize traditional vegetarian dishes**: Choose from the 85.1% of traditional vegetarian options that typically have lower environmental impact
2. **Regional awareness**: Consider South and West Indian dishes for lower-carbon choices
3. **Portion consciousness**: Be mindful of serving sizes, particularly for high-impact dishes
4. **Seasonal eating**: Emphasize dishes that use seasonal, local ingredients

6.2 For Policymakers

1. **Dietary guidelines**: Integrate environmental considerations into national dietary recommendations
2. **Public awareness**: Develop educational campaigns highlighting sustainable traditional food choices
3. **Agricultural policy**: Support farming practices that reduce the carbon footprint of traditional ingredients
4. **Research funding**: Invest in research on sustainable traditional food systems

6.3 For Food Industry

1. **Menu development**: Highlight low-carbon traditional dishes in commercial establishments
2. **Ingredient sourcing**: Prioritize low-impact, locally-sourced traditional ingredients
3. **Preparation methods**: Adopt traditional cooking techniques that minimize energy use
4. **Consumer education**: Provide carbon footprint information for traditional dishes

7. Conclusions

This comprehensive analysis of 753 traditional Indian dishes provides unprecedented insights into the environmental impact of one of the world's most diverse culinary traditions. Key findings include:

1. **Significant dietary impact differences**: The environmental advantages of traditional Indian vegetarian cuisine are confirmed by the 2.38-fold larger carbon footprint of non-vegetarian dishes compared to vegetarian alternatives.
2. **Regional variations exist**: South Indian food has the lowest impact (0.5726 kg CO2e) and continental food has the greatest (0.7079 kg CO2e), indicating that regional dietary choices might affect environmental impact.
3. **Diversity in sustainability**: The vast variety of carbon footprints (0.0000 to 7.5990 kg CO2e) shows that traditional cuisine offers sustainable options in every category.
4. **High-impact concentration**: Only 18.5% of dishes exceed 1.0 kg CO2e, indicating that most traditional preparations have moderate environmental impact.
5. **Cultural sustainability alignment**: Traditional Indian cuisine's emphasis on plant-based foods provides a foundation for environmentally sustainable dietary patterns.

According to the research, traditional Indian food preserves cultural culinary history while providing ample opportunity for sustainable dietary choices. The results back up the inclusion of environmental factors in dietary guidelines while maintaining the wide range of traditional Indian cooking techniques.

This work advances our knowledge of the potential role that traditional food systems can play in mitigating the effects of climate change. The thorough research offers useful advice to help consumers, legislators, and the food business make ecologically conscious choices while upholding traditional culinary customs.

To further maximize the sustainability of traditional Indian cuisine, future studies should investigate the dynamic linkages among regional ingredient systems, traditional cooking techniques, and environmental effect. The study's methods and conclusions can be applied to other traditional cuisines around the world, advancing our understanding of the role that traditional food systems play in sustainable development.

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Data Availability:
The dataset used in this study is publicly available on Kaggle:
https://www.kaggle.com/datasets/umangsinghal5/nutritional-and-carbon- footprint-data-of-indian-diet/code

Conflicts of Interest: The authors declare no conflicts of interest.

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