The Bioscan
AN INTERNATIONAL QUARTERLY JOURNAL OF LIFE SCIENCES
20(1): S.I (1), 114-124, 2025 www.thebioscan.com

Ritual Plants of Maharashtra: Documentation, Analysis, and Cultural Significance

[1]Karle B.A[*], [2]Kulkarni A.A, [3]Deshmukh S.R. [4]Pansare P.A., and [5]Lamrood P.Y

1,4Department of Botany, New Arts, Commerce and Science College, Ahmednagar (Autonomous), Maharashtra, India

2 Department of Statistics, New Arts, Commerce and Science College, Ahmednagar (Autonomous), Maharashtra, India

3Department of Biotechnology, New Arts, Commerce and Science College, Ahmednagar (Autonomous), Maharashtra, India

5Department of Botany, Ahmednagar College, (Affiliated to Savitribai Phule Pune University, Pune), Ahilyanagar, Maharashtra, India

[*]Corresponding author: bhagyashali4444@rediffmail.com

DOI: 10.63001/tbs.2025.v20.i01.S.I(1).pp114-124

KEYWORDS
Documentation, religious ceremonies, rituals, plants, association, analysis

Received on:
10-02-2025

Accepted on:
07-03-2025

Published on:
09-04-2025

ABSTRACT

Festivals are integral to human culture, celebrating significant life events and spiritual occasions. Traditional festivals reflect cultural identity, fostering community and spirituality. Plants play a crucial role in these celebrations worldwide, symbolizing cultural heritage and the human-nature relationship. In India, their significance extends beyond practical use, yet research on their cultural importance remains limited.This study documents and statistically analyzes plant usage in 19 Indian festivals across different seasons. Food-related plants are central to many celebrations, with Haritalika showing the highest plant usage. Arecaceae and Poaceae are the most commonly used families, with key plants including nagli, coconut, mangoes, and nuts. Word cloud analysis highlights prominent plant-related festivals such as Gopalkala, Pola, Mangalagaur, and Diwali.A Chi-square test revealed a highly significant association between festivals and seasons ($X^2 = 820$, df = 72, $p < 2.2e-16$), confirmed by Cramér's V (1) and the contingency coefficient (0.894). Flower and tree usage showed strong associations with Marathi and English months ($\Phi = 0.512$ and $\Phi = 0.410$, respectively). Flower ($\Phi = 0.412$) and powder ($\Phi = 0.417$) usage were significantly linked to festivals, highlighting their importance in religious and celebratory practices. Sentiment analysis assigned scores to plant-related phrases, indicating mild positivity for "food, worshipping" (0.4596) and neutrality for "prasad" and "decoration" (0.0000). Network analysis revealed distinct clusters of festivals and seasons, emphasizing shared cultural and temporal connections. Correspondence analysis biplots showed strong seasonal associations, with Gregorian calendar months exhibiting clearer temporal fixation than the Hindu lunar calendar.This study enhances understanding of the cultural significance of plants in festivals, reinforcing their role in biodiversity conservation and cultural heritage preservation.

INTRODUCTION

Religions and faiths have developed diverse expression of devotion to God. Since Vedic period (1500–500 BCE), people in the Indian subcontinent have honoured nature through diverse rituals.For centuries, indigenous communities worldwide have emphasized the conservation of natural resources. Despite ongoing environmental challenges, much of their biological heritage has been preserved through conservation-oriented socio-cultural and religious traditions. Among these traditions, plant worship is one of the oldest forms of devotion (Chandraasian, 2022; Kavitha*et al.*,2019).Plants, essential for survival, provided food, medicine, and shelter, leading early humans to revere them more than animals. This reverence not only underscored their significance but also contributed to their conservation. Beyond survival, plants hold deep cultural and spiritual value. Sacred species play a vital role in rituals across various religions, making them integral to spiritual and ceremonial practices. (Sahay, 2022). Furthermore, biodiversity conservation through cultural and religious traditions is often more effective and sustainable than relying solely on legislative measures (Geng*et al.*, 2017).

Even before the advent of calendars, humans marked seasonalchanges by observing natural cues such as sprouting of leaves and blooming of flowers. The arrival of a new season was celebrated through rituals using various plant parts,including young leaves, flowers, and fruits. Many plant species were considered sacred and were offered to specific deities as part of religious traditions (Kolte *et al.*, 2012).

In an Indian culture, plants and their parts have been integral to rituals,as Hindu mythology emphasizes their significance, with no festival or religious ceremony considered complete without them (Shende *et al.*, 2021). The tradition of using plants in worship has been passed down through generations, as documented in the Vedas. Despite its long standing history, scientific study on this practice remains limited. Plant worship is one of the oldest forms of devotion in the world (Mandal *et al.*, 2020, Sneh Lata, *et al.*, 2022). Additionally, food culture in India is deeply intertwined with festivals, with each state, village, caste, and community having its own unique culinary traditions. The use of plants in festive cuisine reaches its peak during celebrations (Ritu Kumari, 2024).

Maharashtra, the third-largest state in India, covers an area of approximately 308,000 km². It is located between 15° 35' to 22° 2' north latitude and 72° 40' to 80° 30' east longitude. The state shares its borders with Madhya Pradesh, Gujarat, Chhattisgarh, Andhra Pradesh, Karnataka, and Goa, along with the Union Territory of Dadra and Nagar Haveli. To the west, Maharashtra is bounded by the Arabian Sea, forming anextensive coastline.(Khare, *et al.*, 2020)

The present study documents and analyses the plants used in Maharashtra's festivals and traditional practices celebrated throughout the year. It aims to understand the correlation between festivals, seasonal changes, plant parts used, food culture, and conservation strategies. Maharashtra's festivals are deeply connected to nature, with specific plants playing a crucial role in rituals, offerings, and celebrations. The study investigated the utilization of various plant species and their parts - including leaves, flowers, fruits, roots, and wood - in religious and cultural events. It further explores how these traditions align with seasonal cycles, agricultural practices, and local biodiversity.Additionally, the research highlights the connection between traditional food culture and plant-based offerings, emphasizing the role of seasonal produce in shaping dietary habits.

2. Materials and Methods:

2.1 Data Collection Through Interviews

Festival-related data was collected through interviews using a random sampling method. Participants were selected based on their long-standing experience in celebrating traditional festivals. The interviews focused on gathering information on the common names of plants, plant parts used, their specific roles in festival rituals, associated medicinal properties, and their relevance to conservation. Personal interviews with local community members provided valuable ethnobotanical insights into the cultural significance of various plant species in religious and seasonal celebrations.

2.2 Taxonomic Identification and Literature Review

The scientific names, family classifications, and taxonomic citations of the documented plant species were verified using the International Plant Names Index (IPNI) database to ensure accuracy and standardization. Additionally, information regarding the traditional uses of these plants in religious and cultural contexts was cross-referenced with historical and ethnobotanical literature, including the book *San, VarVrat, Vaikalya.*

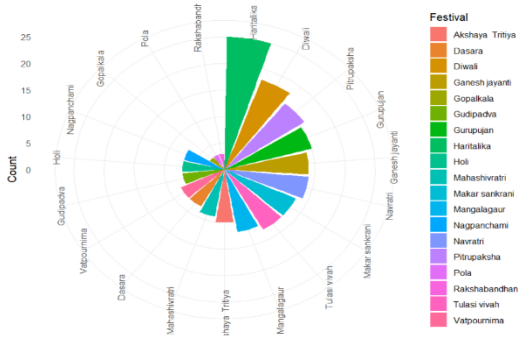
2.3 Data Organization and Statistical Analysis

The collected data was systematically organized in tabular format for clarity and ease of interpretation. Statistical analyses were conducted using R (4.4.2) software and libraries such as - tidyverse, ggplot2, ggpubr, ggcorrplot, reshape2, corrplot, RColorBrewer, wordcloud, gridExtra,ggalluvial,vcd,ggthemes,FactoMineR,factoextra,igraph,ggraph etc.to identify patterns, correlations, and trends related to plant usage across different festivals, seasonal variations, and their broader cultural and ecological implications.

3. Results and Discussion

3.1 In Maharashtra, numerous festivals are celebrated throughout the year, each corresponding to different seasons. The selection and use of various plant species and their parts for these celebrations are influenced by seasonal variations. The following figure (fig.1) illustrates the diverse festivals observed in Maharashtra.

Figure 1: Diversity of festivals celebrated in Maharashtra



The present study investigates the relationship between Indian festivals and plant usage by collecting data from native residents of Maharashtra, India. the association between plant usage in festivals and the corresponding English and Marathi months was analyzed. The use of plants in festivals was correlated with both English and Marathi months. Table 1 demonstrates that the occurrence of festivals in English and Marathi months is largely similar.

Table 1: Occurrence of festivals in English and Marathi months

Sr no	Name of the Festival	Marathi month	English Month	Season
1.	Makar sankranti	Paush	January	Winter
2.	Mahashivratri	Maagh	February	Winter
3.	Holi	Falgun	March	Spring
4.	Gudipadva	Chaitra	April	Spring
5.	Akshaytrutiya	Vaishakh	May	Summer
6.	Vatapornima	Jestha	June	Summer
7.	Nagpanchami	Shravan	August	Monsoon
8.	Rakshabandhan	Shravan	August	Monsoon
9.	Gopalkala	Shravan	August	Monsoon
10.	Manglagauri	Shravan	September	Autumn
11.	Pola	Shravan	September	Autumn
12.	Hartalika	Bhadrapad	September	Autumn
13.	Shriganeshchaturti	Bhadrapad	September	Autumn
14.	Gauripujan	Bhadrapad	September	Autumn
15.	Pitrupakshy	Bhadrapad	September	Autumn
16.	Navratra	Ashwin	October	Autumn
17.	Dussehra	Ashwin	October	Autumn
18.	Diwali	Ashwin	October	Autumn
19.	Tulsivivah	Kartik	November	Pre-Winter

3.2 Seasonal Influence of Plants on Festivals: Food-related plants play a crucial role in various Indian festivals, with their usage varying across different seasons. This study examines the correlation between food-related plant utilization and seasonal festivals, as illustrated in the following fig. 2. The findings indicate that autumn exhibits the highest number of food-related plants (~38 species), likely due to the occurrence of major festivals such as Navratri, Diwali, and Sharad Purnima, which involve significant plant-based food preparations. Monsoon follows with approximately 17 plant species, as festivals like RakshaBandhan and Janmashtami incorporate food plants, albeit to a lesser extent than in autumn.

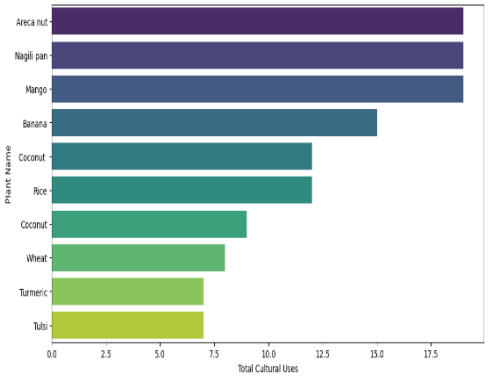
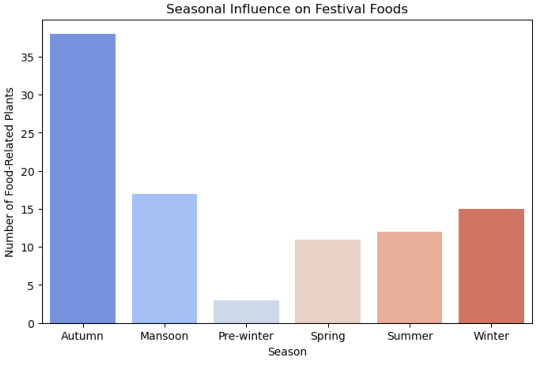


Figure 2: Seasonal influence on food-related plants

Winter, summer, and spring show moderate plant usage (10–16 species), reflecting the presence of food-related traditions in these seasons, though not as prominently as in autumn. Pre-winter records the lowest number of food-related plants (~3 species), suggesting a lower frequency of festivals or a reduced emphasis on plant-based food items during this period.Plant usage plays a significant role in various festivals celebrated in Maharashtra, with different plant species and their parts being utilized for celebrations. We listed top ten plants used in various festivals and depicted in figure 3

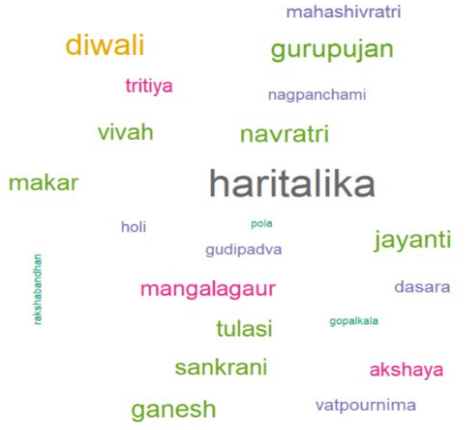


:

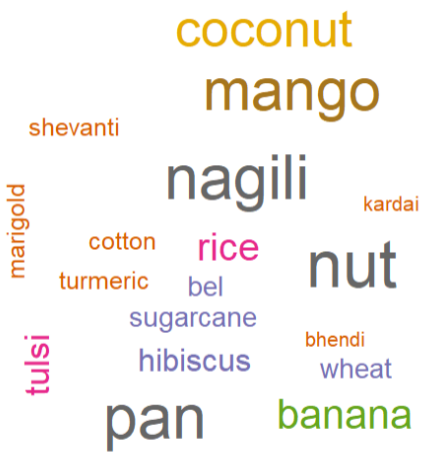
Figure 3. List of top ten plants and their cultural uses

Similarly, a word cloud analysis was conducted to identify the most frequently occurring plants associated with festivals, revealing that Haritalika exhibits the highest plant usage (see fig. 4)

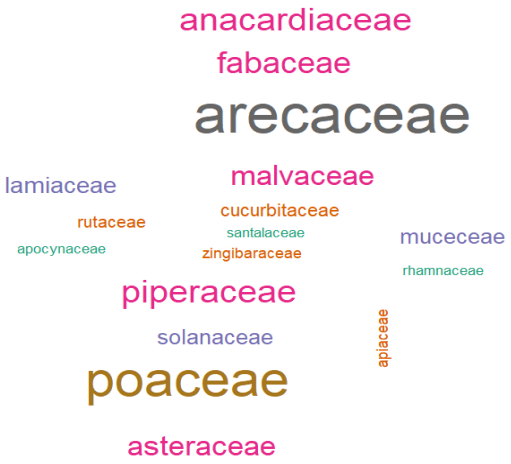
4.a



4.b



4.c



4.d

Figure.4-word cloud analysis a) to identify the most frequently occurring plants b) Purpose of plant utilization and c) Frequently used plants during festival rituals d) commonly used plant family

Worship was identified as the primary purpose of plant utilization across different festivals, with plant families such as Arecaceae and Poaceae being the most commonly used.

Key plants, including *nagli*, coconut, mangoes, and nuts, were frequently associated with festival rituals.

The word cloud visualization highlighted the most prominent festivals involving plant usage, with Gopalkala, Pola, Mangalagaur, and Diwali appearing in larger fonts, indicating their strong connection to plant-based traditions. Other significant festivals, such as Rakshabandhan, Gudipadwa, Tulsi, Akshay Tritiya, and Navratri, also demonstrated notable plant associations. These findings underscore the deep-rooted cultural significance of plants in religious ceremonies, seasonal transitions, and social practices. Additionally, the presence of festivals like Makar Sankranti and PitruPaksha suggests a strong link between plant usage and agricultural or seasonal cycles.

The primary use of plant parts in festivals is for worship, making it the most frequent application. Among the various plant components, food (62) and leaves (60) are the most commonly utilized for religious rituals, followed by fruits (45) and flowers (26), which also hold significant ceremonial importance. Secondary uses of plant parts include gifting, offering (*prasad*), and decoration, though these applications are relatively rare. Gifts are primarily associated with fruits (1), seeds (1), leaves (1), and food (3), while *prasad* offerings commonly involve fruits (7), seeds (2), leaves (3), tubers (1), and twigs (2). Decorative use is minimal, observed only with leaves (1). Among plant components, leaves exhibit the highest versatility, being used across worship (60), gifts (1), *prasad* (3), and decoration (1). Fruits also demonstrate considerable utility, particularly in worship (45) and *prasad* (7). In contrast, plant parts such as trees, powder, rhizomes, stems, twigs, and wood are exclusively used for worship, with no significant role in other categories.

The Chi-square test was conducted to determine whether there is a significant association between festivals and seasons based on plant usage. The results indicate a highly significant relationship (X^2 = 820, *df* = 72, *p*< 2.2e-16), suggesting that plant usage varies systematically across different seasons. However, the warning regarding the chi-square approximation potentially being incorrect indicates that some expected frequencies may be too low, which could affect the reliability of the test. To measure the strength of this association, Cramér's V was calculated, yielding a value of 1, which suggests a very strong relationship between festivals and seasons.The contingency coefficient (0.894) further supports this strong association. While such a high effect size typically indicates a structured relationship rather than a random pattern, it may also suggest an issue with data distribution, such as small sample sizes in certain categories. Post-hoc analysis using standardized residuals and *p*-values revealed that specific festivals exhibit significant associations with particular seasons. For instance, *Akshaya Tritiya*, *Diwali*, and *Haritalika* show strong positive residuals in autumn, whereas *Gopalkala*, *Mangalagaur*, and *Nagpanchami* are more prominent in monsoon. Additionally, *Holi* and *Gudipadva* are significantly associated with spring, and *Makar Sankranti* and *Mahashivratri* show strong associations with winter. These findings suggest that plant usage in festivals follows a seasonal pattern, likely influenced by agricultural cycles, cultural traditions, and ecological availability of plant resources. Similarly, we conducted Chi-Square Post-Hoc Test with BonferroniCorrection to identifywhich festival-season pairs show significant associations (p < 0.05) and the results are represented in the table 2:

Table 2: Chi-Square Post-Hoc Test with Bonferroni Correction showing significant associations between festival-season pairs.

Festival	Season	Interpretation
Akshaya Tritiya	Summer	Strongly associated with summer (p = 0.000)*
Diwali	Autumn	Strongly linked to autumn (p = 0.027)
Gudipadva	Spring	Highly significant for spring (p = 0.000)
Haritalika	Autumn	Strong autumn association (p = 0.001)
Makar Sankranti	Winter	Strong winter festival (p = 0.000)
Mangalagaur	Monsoon	Highly significant monsoon festival (p = 0.000)
Nagpanchami	Monsoon	Strong monsoon association (p = 0.000)
Mahashivratri	Winter	Strong winter association (p = 0.000)
Vatpournima	Summer	Highly linked to summer (p = 0.000)

* (*p*< 0.05)

These results suggest that certain festivals have **strong seasonal associations**, with some occurring significantly more frequently in specific seasons.

The Chi-square test was also conducted to examine the association between plant parts and time-related categories (Marathi months, English months, and festivals). The results indicate a statistically significant relationship between flower usage and both Marathi and English months (x^2 = 22.21, *p* = 0.0083), suggesting that flower usage varies significantly across months. This highlights the cultural and ritualistic importance of flowers in different seasonal and religious contexts.To assess the strength of these associations, the Phi (Φ) coefficient was

calculated (see table 3). A Phi value greater than 0.40 indicates a strong association. Flower usage demonstrated a strong relationship with Marathi months (Φ = 0.512) and English months (Φ = 0.512), reinforcing the seasonal and cultural dependence on flowers. Similarly, tree usage showed a strong association with Marathi (Φ = 0.410) and English months (Φ = 0.410), indicating that trees play a significant role in monthly traditions. Additionally, flower (Φ = 0.412) and powder (Φ = 0.417) usage were strongly associated with festivals, suggesting that these plant parts are integral to religious and celebratory practices. Overall, the results confirm that specific plant parts are closely linked to temporal patterns, reflecting their deep-rooted significance in cultural and seasonal traditions.

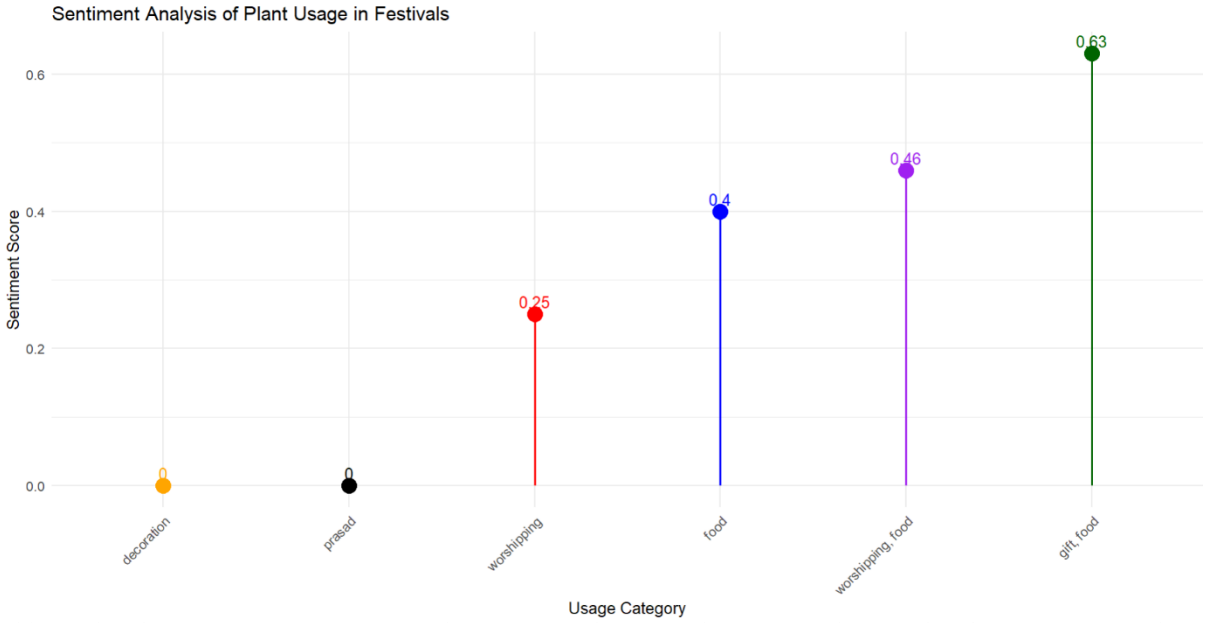


Table 3: The Chi-square test for examining the association between plant parts and time-related categories (Marathi months, English months, and festivals).

Category	Plant Part	Coefficient of Association (Φ)*
Marathi Month	Flower	0.512
English Month	Flower	0.512
Marathi Month	Tree	0.410
English Month	Tree	0.410
Festival	Flower	0.412
Festival	Powder	0.417

*

Strong Associations (Φ > 0.40):

The correlation between Indian festivals and plant conservation strategies highlights the significant role of traditional ecological knowledge in sustainable practices. Thematic analysis reveals that agricultural festivals such as Makar Sankranti and PitruPaksha align with seasonal cycles, emphasizing their influence on plant utilization. Significant chi-square test results indicate a strong association between flowers and specific months, suggesting a seasonal approach to plant use that may contribute to conservation efforts. The widespread use of leaves, fruits, and seeds in religious practices ensures their continuous cultivation, indirectly supporting biodiversity conservation. Additionally, the versatility of plant parts, particularly leaves, extends beyond worship to include Prasad, decoration, and gifting, underscoring their importance in cultural sustainability. Similarly, the relationship between Indian festivals and food culture is shaped by seasonal influences, with autumn exhibiting the highest number of food-associated plants (~38 species), driven by major festivals such as Diwali, Navratri, and Sharad Purnima. The integral role of food in worship is evident in the prominence of offerings such as food (62), fruits (45), and seeds (27), reflecting the deep-rooted connection between culinary traditions and ritualistic practices. Furthermore, festivals such as Gopalkala, RakshaBandhan, and Makar Sankranti are closely linked to food-based traditions, reinforcing the intricate relationship between Indian festivals and food culture.

3.3 Sentiment Analysis:

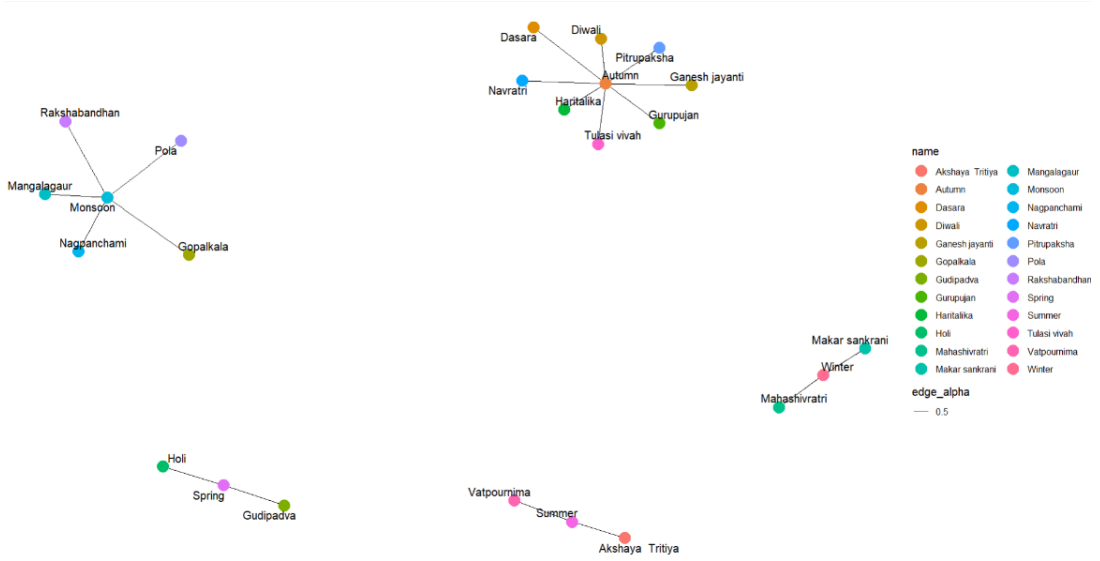
The sentiment scores assigned to each phrase quantify the degree of positivity or negativity based on sentiment analysis (See fig. 5). Phrases such as "**food, worshipping**" and "**worshipping, food**" have a sentiment score of **0.4596**, indicating a mildly positive sentiment, suggesting they are perceived as somewhat favorable or neutral but not strongly positive. The phrase "**worshipping**" has a sentiment score of **0.2500**, representing a neutral to slightly positive sentiment. Meanwhile, "**prasad**" and "**decoration**" both have sentiment scores of **0.0000**, indicating a completely neutral sentiment, likely reflecting their use as more objective or non-emotional terms. Overall, the sentiment scores remain relatively low, suggesting that the emotional tone conveyed by these terms is predominantly neutral or mild rather than strongly positive or negative. This analysis provides insight into how specific terms or their combinations, such as "**food" and "worshipping**", are perceived within the dataset, contributing to a broader understanding of their contextual sentiment.

Figure 5: The sentiment scores assigned to each phrase (Scores approaching 1 indicate a more positive sentiment, while those near 0 suggest a neutral sentiment and scores closer to -1 would signify a negative sentiment).

3.4 Network Analysis

Network analysis is a powerful tool for visualizing and understanding relationships between entities, particularly in complex datasets involving interconnected elements. The given network graph (fig. 6) illustrates associations among various Hindu festivals, seasons, and cultural practices, revealing patterns and clusters that might not be immediately apparent through traditional statistical methods.

Figure 6: Network analysis illustrating associations among various Hindu festivals, seasons and cultural practices.



Distinct clusters indicate closely related festivals and seasons, suggesting that certain cultural and religious practices share thematic or temporal connections. For example, **Diwali, Pitru Paksha, and Ganesh Jayanti** form a closely linked cluster, reflecting their temporal proximity and cultural significance, whereas **Makar Sankranti and Mahashivratri** are distinct but connected through their seasonal associations. Similarly, festivals such as **Holi and Gudipadva** are linked within the context of **Spring**, highlighting the seasonal influence on their celebration. The network structure facilitates the identification of key nodes (central festivals) and their peripheral associations, aiding in the interpretation of cultural linkages. The use of color coding further enhances the clarity of the network, allowing for the differentiation of categories.Such an approach is invaluable for comparative religious studies, ethnobotanical research, and cultural anthropology, as it enables the systematic exploration of connections between traditions, time periods, and natural cycles, contributing to a deeper understanding of socio-cultural patterns. Furthermore, to effectively visualizes the intricate relationships between festivals and plant species, advanced network analysis was carried out and presented in fig.6.

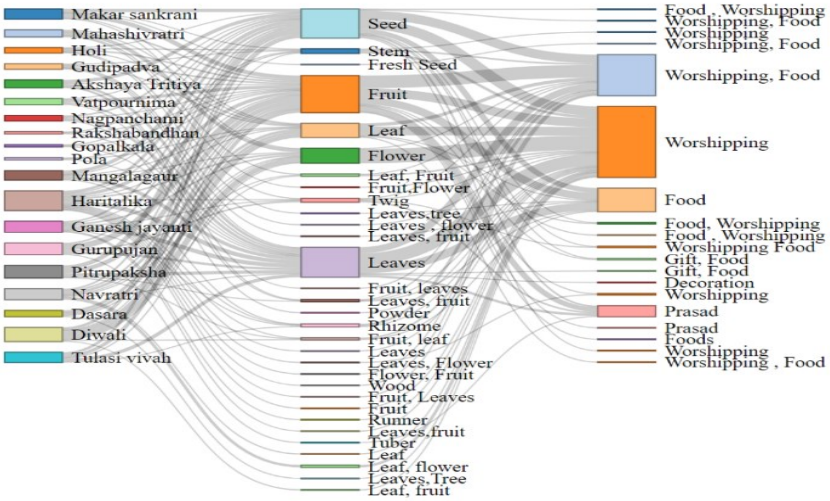
Figure 7: Advanced network analysis depicting the intricate relationships between festivals and plant species (Nodes with red colour indicate festivals and green nodes represent plant species)

The results demonstrating the interconnectedness of cultural and botanical elements in Hindu traditions. Each node represents either a festival (red) or a plant (green), while edges indicate associations between them, such as the use of specific plants in religious rituals, offerings, or seasonal festivities.The dense clustering of plant nodes suggests that many plant species are integral to multiple festivals, highlighting their cultural and ritual significance. Furthermore, the network structure allows for the identification of central and highly connected nodes, revealing key festivals that involve a wide variety of plant species and vice versa. This approach provides a systematic means of understanding the role of ethnobotanical resources in religious

and social practices, offering insights into traditional ecological knowledge. The application of network analysis in such studies enhances the interpretation of cultural heritage, biodiversity conservation, and the sustainable use of plant resources in traditional practices. By uncovering patterns that might not be evident in tabular data, this method contributes to interdisciplinary research in botany, anthropology, and religious studies.

The Sankey diagram (fig. 8) provides a comprehensive visualization of the flow and distribution of plant parts used across various Hindu festivals, along with their associated functions such as worshipping and food.

Figure 8: Sankey diagram showing the flow and distribution of plant parts used across various Hindu festivals, along with their associated functions such as worshipping and food.



Unlike network and advanced network analyses, which emphasize the structural relationships and connectivity between elements, the Sankey diagram highlights the quantitative flow of associations, illustrating the extent and pathways of plant utilization. The thickness of the connections in the Sankey diagram represents the strength or frequency of associations, making it easier to discern which plant parts are most commonly used and for what purpose. This approach allows for a more intuitive understanding of the hierarchical relationships between festivals, plant parts, and their uses, which is less apparent in traditional network visualizations. Furthermore, the Sankey diagram provides an additional layer of insight by clearly mapping out the specific plant parts (e.g., leaves, flowers, fruits, seeds) that contribute to different cultural practices, information that is not directly extracted from standard network analysis. This visualization is particularly valuable in ethnobotanical studies, as it facilitates the identification of key plant resources in religious traditions, helping to inform conservation priorities and cultural heritage research. The Sankey diagram provides crucial insights into the ethnobotanical significance of plants in Hindu festivals and rituals, revealing patterns of plant part utilization and their associated functions. One of the key findings is that certain plant parts, such as **leaves, flowers, and fruits**, are predominantly associated with multiple festivals, indicating their widespread ritualistic and cultural importance. For instance, **leaves and flowers are extensively used across different festivals**, highlighting their symbolic and decorative roles in worship and offerings. Additionally, **fruits are commonly linked to both worshipping and food**, emphasizing their dual function as sacred offerings and consumables during religious ceremonies.

Another notable observation is that some festivals, such as **Makar Sankranti, Holi, and Diwali**, are associated with a diverse range of plant parts, suggesting a broader botanical influence in their traditional practices. In contrast, certain festivals like **Tulasi Vivah and Pitru Paksha** exhibit a more specific reliance on particular plant parts, such as leaves, which aligns with the cultural significance of sacred plants like *Ocimum tenuiflorum* (Tulsi). The diagram also reveals that **worshipping is the primary function associated with plant use**, followed by food-related applications. This underscores the integral role of plants in religious devotion and ritualistic practices.

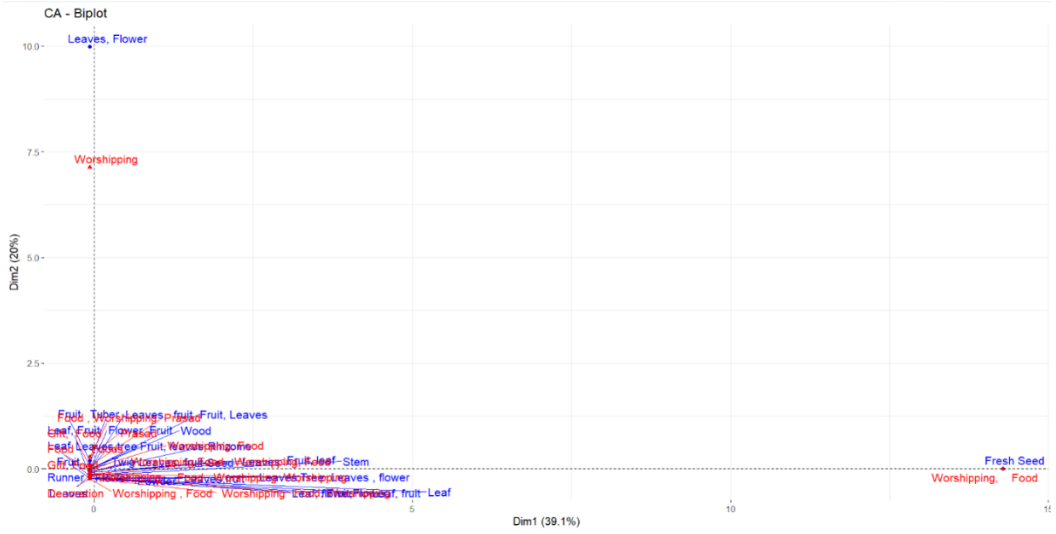
Furthermore, the Sankey diagram effectively differentiates between various plant parts, such as **seeds, stems, twigs, rhizomes, and powders**, which are less prominently used but still hold specific ritualistic significance. For example, **seeds and fresh seeds are associated with fewer festivals but are particularly linked to auspicious ceremonies** where germination and new beginnings are symbolized. The presence of **wood and tree-related associations** suggests the inclusion of sacred trees in Hindu rituals, which is a finding that might be overlooked in network analysis alone.

The Sankey diagram highlights the profound cultural dependence on plants in Hindu religious traditions, emphasizing deep spiritual connections between nature and faith. It reveals the dominance of leaves, flowers, and fruits in rituals, where flowers symbolize purity and devotion, leaves serve as offerings, and fruits function as both sacred gifts and food. The diagram also illustrates festival-specific plant usage, showing that certain festivals favor particular plant parts, likely influenced by seasonal availability and religious customs. Additionally, it underscores that worship is the primary purpose of plant use, reinforcing the central role of nature in Hindu spiritual practices. Unlike network analysis, which focuses on relational structures, the Sankey diagram enhances visualization by quantifying the intensity of associations, providing a clearer understanding of the frequency and significance of plant use in various ritualistic contexts.

3.5 Correspondence biplot Analysis:

The correspondence analysis biplot illustrates the relationships between categorical variables, specifically showcasing the associations between plant parts (Leaves, Flower, Fruit, Wood, etc.) and their associated usage categories (Worshipping, Food, etc.). The plot's axes, Dim1 and Dim2, represent the principal components explaining 39.1% and 20% of the variance, respectively, summarizing the major patterns of association. Objects positioned close together on the biplot indicate strong associations. For instance, "Fresh Seed" and "Worshipping, Food" are located in proximity along the positive Dim1 axis, suggesting that fresh seeds are frequently associated with food and worship practices. Conversely, "Leaves, Flower" is situated distantly along the positive Dim2 axis, indicating its distinct association pattern, likely being less related to the use categories clustered around the origin. The biplot's importance lies in its ability to visually represent complex categorical data, enabling researchers to identify dominant patterns and interpret the underlying relationships between variables efficiently. This visualization aids in understanding the cultural or ecological significance of plant parts based on their associated uses, facilitating further hypothesis generation and targeted analyses in ethnobotanical or ecological studies.

Fig. 9a: Correspondence Analysis of Hindu Festivals Across Seasons

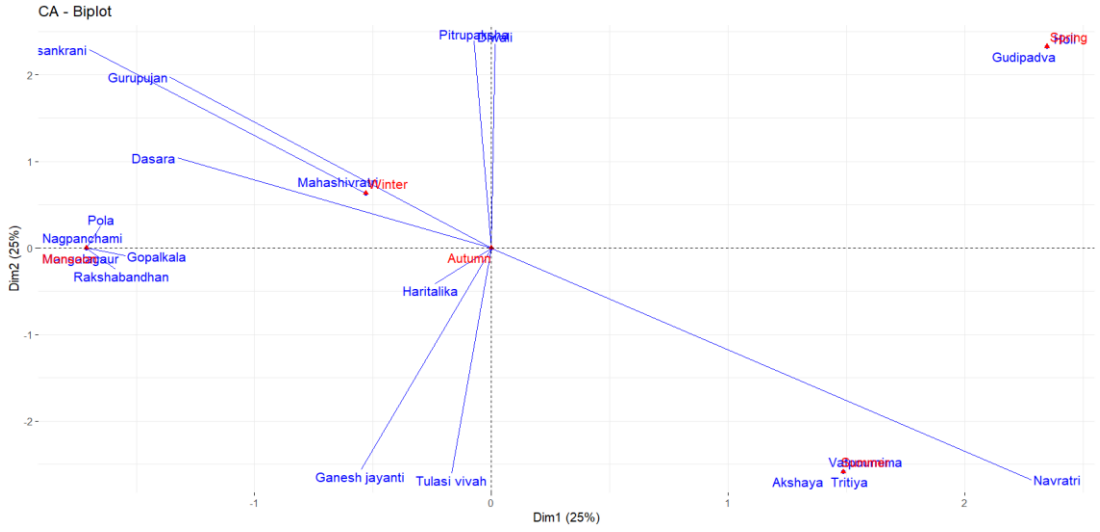


The correspondence biplot (see fig. 9 a through d) were also generated for Festival and Season, Marathi months and festivals and English months and are represented below:

Correspondence Analysis of Hindu Festivals Across Seasons

This study employs correspondence analysis (CA) to explore the seasonal distribution of Hindu festivals and their associations with different time periods within the Hindu lunar calendar. The CA biplot effectively visualizes the relationships between various festivals and their respective seasons, highlighting significant trends and clustering patterns. The correspondence analysis biplot (Figure X) presents the distribution of Hindu festivals (blue) in relation to the seasonal categories (red). The first two dimensions explain 50% of the total variance (Dim1: 25%, Dim2: 25%), indicating a substantial contribution of these axes in capturing the relational structure between festivals and their corresponding seasons.

9b



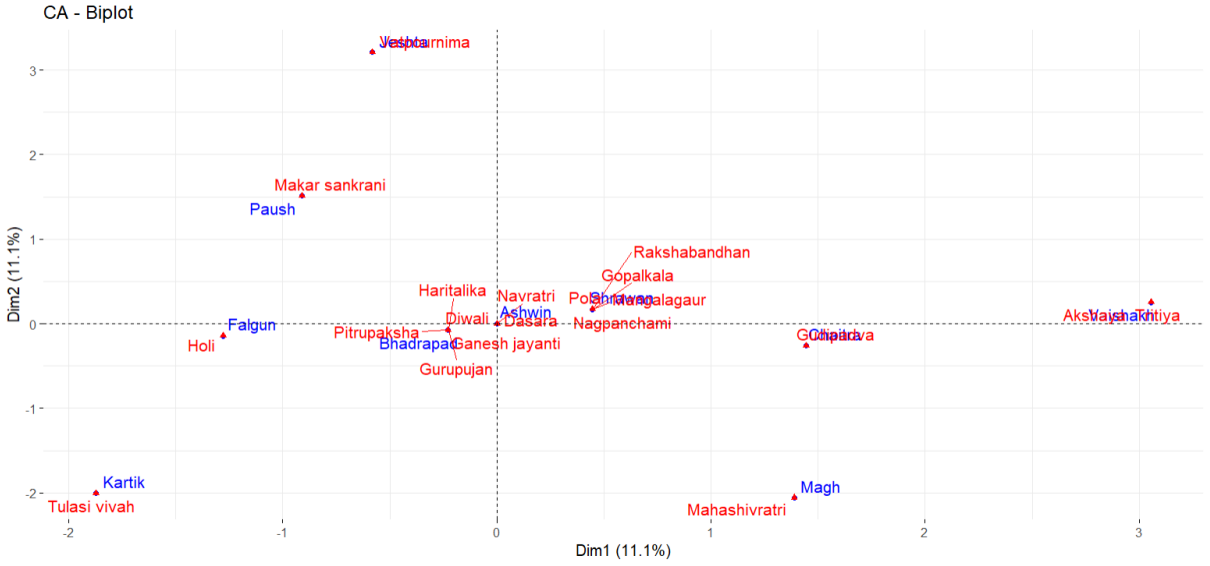
Distinct clusters of festivals are observed along the two dimensions, suggesting strong seasonal associations. Spring-associated festivals, such as Gudipadva, are positioned in the upper-right quadrant, demonstrating a strong correlation with the spring season. Autumn festivals, including Navratri, Purnima, and Akshaya Tritiya, are located in the lower-right quadrant, indicating their alignment with autumn. Winter festivals, such as Mahashivratri, are positioned centrally but show a directional association with winter. Monsoon and other seasonal festivals, such as Haritalika, TulasiVivah, and Ganesh Jayanti, cluster in the lower-left quadrant, demonstrating a spread across different time periods.

The proximity of festivals to their respective seasons suggests strong correlations, with Gudipadva displaying a pronounced association with Spring, Navratri with Autumn, and Mahashivratri with Winter. Festivals such as Rakshabandhan, Mangalagaur, and Pola exhibit close grouping, suggesting similar seasonal or cultural significance. The vectors in the biplot illustrate the direction and strength of associations. Longer arrows indicate stronger seasonal linkages. The placement of Navratri and Purnima confirms their autumnal significance, while Gudipadva remains distinctly aligned with spring. Certain festivals exhibit a more distributed association, implying variability in their seasonal classification across different cultural contexts.

The CA biplot effectively delineates the seasonal structure of Hindu festivals, revealing distinct clusters and associations. The findings underscore the deep-rooted link between cultural festivities and ecological cycles, emphasizing the role of seasonality in religious and social observances. This analysis provides a quantitative basis for understanding the temporal patterns of Hindu festivals, contributing to the broader discourse on ethnobotany, cultural traditions, and seasonal rituals. Future research may explore the influence of regional variations on festival timings and their ecological significance, integrating additional cultural and climatic variables to further refine these associations.

Correspondence biplot for Marathi Months and Festivals

This study employs correspondence analysis (CA) to investigate the relationships between Hindu festivals and their associated lunar months, effectively illustrating these associations through a CA biplot that reveals key seasonal trends and clustering patterns. The biplot (Figure X) presents the distribution of Hindu festivals (red) in relation to their corresponding lunar months (blue), with the first two dimensions explaining approximately 22.2% of the total variance (Dim1: 11.1%, Dim2: 11.1%), capturing a substantial proportion of variability in the dataset. The analysis highlights clear clustering patterns, with Vaisakh-related festivals, such as Akshaya Tritiya, distinctly positioned in the far-right quadrant, while spring and summer festivals, including Gudipadva, align with Chaitra and Vaishakh in the mid-right region. Winter festivals, such as Mahashivratri, are found in the **9c:**



placement, whereas TulasiVivah, positioned in the lower-left quadrant, exhibits a strong connection to Kartik. Holi and Falgun cluster in the upper-left quadrant, marking the transition from winter to spring, while Magh festivals, including Mahashivratri, in the lower-right quadrant highlight their association with mid-winter observances. Overall, the CA biplot effectively delineates the temporal structure of Hindu festivals, reinforcing their intrinsic link to the lunar calendar and seasonal cycles. These findings contribute to broader discussions in ethnobotany, cultural traditions, and lunar-based rituals, providing a quantitative basis for understanding temporal patterns in Hindu religious observances. Future studies could explore regional variations in festival timings and their ecological significance, integrating additional environmental and socio-cultural factors to refine these temporal associations.

Correspondence biplot for English Months and Festivals

The Correspondence Analysis (CA) biplot effectively visualizes the relationships between Hindu festivals and their corresponding Gregorian months, with the first two dimensions accounting for 22.2% of the total variance (Dim1: 11.1%, Dim2: 11.1%), capturing a significant portion of the dataset's underlying structure. The analysis reveals distinct clustering patterns, indicating strong temporal associations between festivals and specific months. *Makar Sankranti* is uniquely positioned in the far-left quadrant, reinforcing its fixed association with January, while *Holi* clusters near March, marking the transition to spring. *Akshaya Tritiya* aligns with May, *Rakshabandhan, Gopalkala, and Nagpanchami* cluster in the upper-right quadrant, reflecting their monsoon-season significance, and *Diwali, Dasara, and Vatpournima* are centrally positioned, corresponding to October and November. *Mahashivratri*, placed in the lower-right quadrant, highlights its association with late winter observances. The spatial proximity of *Dasara, Navratri, and Diwali* suggests their shared seasonal relevance, while *Rakshabandhan, Gopalkala, and Pola* exhibit a strong link to monsoon months. The biplot also shows directional trends, with festivals distributed across seasons along the two axes. Centrally positioned festivals, such as *Diwali and Vatpournima*, indicate broad cultural significance, while *Ganesh Jayanti, PitruPaksha, and Guru Pujan* align with the post-monsoon period. The placement of *Manglagaur and Pola* in the upper-right quadrant further confirms their late-monsoon associations. Overall, the CA biplot effectively delineates the structured timing of Hindu festivals, reinforcing their deep-rooted links to seasonal cycles. This study provides a quantitative perspective on the temporal patterns of Hindu religious observances, offering insights into their seasonal and cultural significance. Future research could explore regional variations in festival timings, incorporating climatic and ecological influences to refine these temporal associations.

lower quadrant, reinforcing their association with the lunar month of Magh, whereas autumn festivals like Diwali, Navratri, and Ashwin-related celebrations cluster near the center, reflecting their widespread cultural and temporal significance. The proximity of festivals to their respective lunar months suggests strong seasonal linkages, with Gudipadva aligning distinctly with Chaitra, Rakshabandhan with Shravana, and Tulasi Vivah with Kartik. The placement of Diwali and Ashwin-related festivals at the intersection of multiple vectors suggests their broad cultural relevance at the transition between monsoon and autumn, while Bhadrapada-based Haritalika and Ganesh Jayanti exhibit close clustering, confirming their shared temporalindicating stronger associations. The distinct positioning of Jyeshtha Purnima in the upper quadrant suggests a unique temporal

9d:

Comparison of Correspondence Biplots: Hindu Festivals and Their Associations with Lunar and Gregorian Months

3.6 Overview of Analysis

The correspondence analysis (CA) biplots illustrate the temporal relationships between Hindu festivals and their corresponding months, one based on the lunar calendar and the other on the Gregorian calendar. Both analyses capture 22.2% of the total variance (Dim1: 11.1%, Dim2: 11.1%), providing meaningful insights into the seasonal structure of Hindu religious observances. While both visualizations reveal strong seasonal clustering patterns, notable differences arise due to the fundamental distinctions between the lunar and Gregorian calendar systems.

3.7 Similarities in the Biplots

1. Seasonal Clustering of Festivals

Both biplots exhibit distinct seasonal clustering of Hindu festivals, emphasizing their strong association with seasonal cycles. Festivals celebrated during spring and summer, such as Holi and Akshaya Tritiya, are positioned close to their respective months. Similarly, autumn festivals like Diwali and Dasara cluster together, confirming their temporal and cultural proximity. Winter festivals, including Mahashivratri, consistently appear in the lower quadrants of both biplots, reinforcing their late-winter placement.

2. Strong Associations with Specific Months

Certain festivals exhibit distinct placement patterns in both biplots, reflecting their fixed seasonal occurrence. For example, Makar Sankranti is positioned separately from other festivals due to its fixed solar date (January 14/15), making it independent of lunar variations. Holi consistently aligns with March/Falgun, confirming its well-established seasonal transition from winter to spring. Additionally, monsoon-season festivals such as Rakshabandhan, Gopalkala, and Nagpanchami cluster together in both representations, highlighting their seasonal significance.

3. Broad Cultural Relevance of Centrally Positioned Festivals

Major festivals such as Diwali, Dasara, and Vat Pournima are centrally positioned in both biplots, suggesting their widespread observance and broad seasonal significance. Similarly, festivals like Ganesh Jayanti, PitruPaksha, and Guru Pujan appear consistently in post-monsoon periods across both visualizations, reinforcing their alignment with agricultural and cultural cycles.

3.8 Differences in the Biplots

1. Variability in Gregorian vs. Lunar Calendar Placement

The Gregorian calendar biplot displays an even distribution of festivals across months, as this system follows a fixed annual structure. In contrast, the lunar calendar biplot shows greater clustering and overlapping of festivals, reflecting the shifting nature of lunar months across years. Festivals that strictly adhere to the lunar calendar, such as Diwali and Navratri, exhibit a broader distribution in the lunar biplot but are more precisely positioned in October–November in the Gregorian representation.

2. Positioning of Specific Festivals Due to Lunar Month Variability

Certain festivals show variation in placement between the two biplots due to the flexible nature of lunar months. For example, Tulasi Vivah appears in the lower-left quadrant of the lunar biplot, aligning closely with Kartik, while in the Gregorian biplot, it is positioned near November but with a slight spread, reflecting its variable occurrence in mid-to-late autumn. Similarly, Jyeshtha Purnima appears more distinctly in the upper quadrant of the lunar biplot, whereas in the Gregorian biplot, its placement is more diffused due to its shifting alignment with the solar calendar.

3. Impact of Fixed-Date Festivals in the Gregorian Representation

The Gregorian biplot distinctly isolates fixed-date festivals like Makar Sankranti, whereas the lunar biplot demonstrates stronger connections between festivals due to the structured nature of the Hindu lunar calendar. The Gregorian system enforces a rigid month-wise distribution, whereas the lunar system naturally clusters related festivals within a shared temporal range.

4. Directional Trends and Seasonal Impact

The Gregorian calendar biplot presents a linear seasonal progression, facilitating a clear visualization of how festivals follow a structured spring-summer-autumn-winter cycle. In contrast, the lunar calendar biplot captures seasonal fluctuations and the relative movement of festivals across years, reflecting a more dynamic temporal pattern influenced by lunar cycles.

3.9 Major Findings and Insights

1. Stronger Month-Wise Associations in the Gregorian Biplot

Festivals exhibit clearer alignment with specific months in the Gregorian biplot, reinforcing the stability of the solar-based system in capturing long-term seasonal trends.

2. Greater Flexibility and Overlapping in the Lunar Biplot

The lunar-based system demonstrates nuanced clustering, revealing how certain festivals shift slightly relative to one another depending on the lunar cycle. This flexibility highlights the adaptability of religious observances to lunar adjustments.

3. Festivals with the Strongest Temporal Fixation

Makar Sankranti remains highly isolated in both biplots due to its fixed solar positioning. Festivals such as Holi, Diwali, Navratri, Rakshabandhan, and Mahashivratri exhibit strong month-wise clustering in both systems, reinforcing their well-established seasonal timing.

4. Potential Research Directions

The lunar calendar biplot suggests that certain festivals may experience gradual shifts over decades due to lunar adjustments, warranting further exploration of long-term temporal variations. Additionally, investigating regional differences in festival observances could provide deeper insights into how local cultures interpret lunar and seasonal alignments. Future research should also examine correlations between festival timing and climatic or agricultural cycles to better understand the ecological rationale behind specific seasonal celebrations.

CONCLUSION

The comparison of the two biplots highlights both the seasonal stability of Hindu festivals in the Gregorian calendar and the dynamic flexibility of their placement within the lunar calendar. While the Gregorian biplot offers a structured month-wise representation, the lunar biplot captures subtle shifts and clustering, reflecting the traditional timing of religious observances. These findings emphasize that Hindu festivals are deeply rooted in astronomical cycles and seasonal transitions, reinforcing the importance of lunar-based ritual timing in religious traditions. Further research should explore how long-term lunar shifts influence festival observances and whether regional adaptations have resulted in variations in festival dates over centuries.

REFERENCES

- Satish Chandraasian, (2022). Documentation of the plant use in different Hindu ritual in Uttarakhand India Journal of Ethanobiology. *Asian Journal of Ethnobiology*, 19 (2): 92-101.
- R Kavitha, R Pandiyalakshmi, P Kalaimathi and A Sarvalingam, (2019). Ritual plant used by Religious Cultural and Rural societies of Virudhunagar District (South Tamil Nadu) India. *Trends in Kalis Research*, 12 (1):154-160.
- Sahaya Mary C, Asha D R (2022). Traditional cuisine used during harvest festivals in India. *International Journal of Multidisciplinary Research and Development*, 9(9):77-82
- Geng, Y., Hu, G., Ranjitkar, S., & others. (2017). The implications of ritual practices and ritual plant uses on nature conservation: A case study among the Naxi in Yunnan Province, Southwest China. *Journal of Ethnobiology and Ethnomedicine, 13*, 58.
- R. R. Kolte, R. S. Kulkarni, P.V.Shinde, H. K. Padvekar,V.G.Magadum, S. A. Apate (2012).Studies on the ethno-medicinal plants used on the occasion of festivals with special reference to Ratnagiri district from Maharashtra state. Conference on*Recent innovative Trends in plant science, Panvel, Maharashtra*. 1-5.
- Shende, J. J., &Dalal, L. P. (2021). Studies on the ethno-medicinal plants used at the occasion of festivals in Wardha District, Maharashtra State, India. *International Journal of Innovative Research in Technology, 8*(4), 41-52.
- Ushashee Mandal, Monalisa Panda, SagarikaParida and GyanranjanMahalik (2020). Plant Sources used for celebrating Hindu Ritual Makar Sankranti the Uttarayan Movement of Sun. *Indian Journal of Natural Sciences,* 10(59):18548-18551.
- SnehLata, Sheetal Sharma and Chitra Maurya (2022). Traditional use of Plants in Various Rituals and Ceremonies Among Tharu Tribe of Udham Singh Nagar Kumaun Himalaya Uttarakhand India. *Plant Archives,* 22(1):334-342
- RituKumari (2024). Indian Festivals: A Booster Dose for the Indian Economy. *International Journal of Economics, Finance and Management Sciences.* 12(6): 484-493.
- Khare, U., Thakur, P., & Joshi, P. (2020). Temporal changes in urban population in Maharashtra state using GIS.*IOSR Journal of Humanities and Social Science (IOSR-JHSS), 25*(10-2), 1-10.