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Original Research Article

Epidemiological Trends and *Plasmodium* species Distribution of Malaria in Dakshina Kannada and Shivamogga Districts, Karnataka, India (2019-2023)

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ABSTRACT

Background: Malaria remains a public health concern in specific endemic pockets of India despite a substantial overall decline in incidence. Karnataka has shown marked regional variation in malaria transmission patterns, influenced by ecological, demographic, and vector-related factors. Understanding district-level epidemiological trends and *Plasmodium* species distribution is essential for sustaining malaria elimination efforts.
Objectives: The present study aimed to analyse the epidemiological trends, age- and gender-wise distribution, spatial patterns, and *Plasmodium* species distribution of malaria cases reported from Dakshina Kannada and Shivamogga districts of Karnataka over a five-year period (2019–2023).
Methods: A retrospective observational study was conducted using secondary data from laboratory-confirmed malaria cases collected from Primary Health Centres across both districts. Data were analyzed for year-wise trends, demographic characteristics, spatial distribution at taluka and PHC levels, and parasite species composition. Descriptive statistics were applied, and results were expressed as frequencies and percentages.
Results: A pronounced decline in malaria cases was observed in Dakshina Kannada, with a reduction of over 95% from 2019 to 2023, while Shivamogga reported consistently low case numbers throughout the study period. Males and individuals aged ≤50 years constituted the majority of malaria cases in both districts. *Plasmodium vivax* was the predominant species in Dakshina Kannada, whereas *Plasmodium vivax* was the dominant species in Shivamogga. Spatial analysis revealed clustering of cases in urban talukas and PHCs, particularly in Dakshina Kannada.
Conclusion: The study demonstrates a significant reduction in malaria burden in the study areas, indicating progress toward malaria elimination. However, persistent age- and gender-related vulnerability, along with marked regional differences in *Plasmodium* species distribution, highlights the need for continued district-specific surveillance and targeted control strategies to prevent resurgence.

Keywords: Malaria, Epidemiology, *Plasmodium* species, Dakshina Kannada, Shivamogga, Karnataka

1. INTRODUCTION

Malaria is a major vector-borne parasitic disease of global public health importance, caused by protozoan parasites of the genus *Plasmodium* and transmitted through the bite of infected female *Anopheles* mosquitoes [1, 2]. Despite sustained global control efforts, malaria continues to affect millions of people annually, particularly in tropical and subtropical regions. According to the World Health Organization [3], malaria remains a leading cause of morbidity and mortality in low- and middle-income countries, with the South-East Asia region contributing significantly to the global disease burden.

India bears a substantial proportion of malaria cases in the South-East Asia region. Although a declining trend in malaria incidence has been reported over the past two decades, the disease persists in localized endemic pockets due to ecological diversity, climatic variability, population migration, and uneven implementation of control measures [4,5]. The heterogeneous distribution of malaria across India underscores the importance of region-specific epidemiological studies to support elimination strategies. Karnataka, a southern Indian state with diverse climatic zones, has historically been categorized as a malaria-endemic region. Earlier epidemiological assessments indicated that Karnataka contributed a notable share of India's malaria burden, particularly during the late twentieth century. However, a comprehensive analysis by [4] demonstrated a significant decline in malaria incidence in Karnataka between 2001 and 2011, with an overall reduction of nearly 90%, attributed to strengthened surveillance, vector control measures, and improved case management. Despite this progress, district-level heterogeneity in malaria transmission continues to be evident within the state.

Dakshina Kannada district, located along the western coastal belt of Karnataka, has long been recognized as a hotspot for urban malaria. Studies have linked the high malaria burden in this region to heavy monsoonal rainfall, high humidity, rapid urbanization, construction activities, and migration of labor populations [6, 7, 8]. Entomological investigations have identified *Anopheles stephensi* as a major vector responsible for urban malaria transmission in coastal Karnataka, particularly in construction sites and peri-domestic environments [9, 10]. Recent evidence suggests that malaria transmission in coastal Karnataka is currently in a declining phase. An exploratory entomological study conducted by a researcher [9] in Dakshina Kannada and Udupi districts reported low densities of malaria vectors and absence of detectable *Plasmodium* infection in sampled anopheline mosquitoes. These findings indicate reduced transmission intensity but also highlight the continued presence of competent vectors, emphasizing the need for sustained epidemiological and entomological surveillance during the elimination phase.

In contrast, Shivamogga district, situated in the Malnad region of the Western Ghats, represents a distinct ecological setting characterized by forest cover, river systems, and seasonal rainfall. Forest-associated and rural malaria transmission in such regions has been influenced by environmental factors, vector breeding habitats, and occupational exposure [4]. Although Shivamogga reports comparatively fewer malaria cases than coastal districts, the presence of malaria vectors and conducive ecological conditions necessitates continuous monitoring to prevent resurgence. Demographic factors such as age and gender play a critical role in malaria epidemiology. Multiple studies from Karnataka and other parts of India have consistently reported a higher prevalence of malaria among males and individuals in the economically productive age group, often attributed to outdoor occupational exposure, migration, and behavioural factors [11, 12]. Understanding these demographic patterns is essential for designing targeted public health interventions.

The distribution of *Plasmodium* species is another key determinant of malaria epidemiology and control [13, 14]. In India, *Plasmodium vivax* and *Plasmodium falciparum* are the predominant species, with *P. vivax* historically dominating in Karnataka. Long-term surveillance data indicate a declining *P. falciparum* to *P. vivax* ratio in the state, reflecting the impact of improved diagnostics, treatment protocols, and vector control strategies [4]. Monitoring species distribution remains crucial, as different *Plasmodium* species are associated with varying clinical severity, transmission dynamics, and treatment outcomes. Integrating epidemiological data from human malaria cases with ecological and entomological ev

idence provides a comprehensive understanding of malaria dynamics, particularly in regions approaching elimination. The declining vector density reported by a researcher [15], when interpreted alongside human case surveillance data, underscores the importance of maintaining vigilance to prevent re-emergence. In this context, the present study was undertaken to analyse the epidemiological trends and *Plasmodium* species distribution of malaria in Dakshina Kannada and Shivamogga districts of Karnataka over a five-year period (2019–2023). The study aims to assess year-wise trends, demographic patterns, spatial distribution at taluka and primary health centre levels, and parasite species composition, thereby generating region-specific baseline data to support malaria control and elimination efforts.

2. MATERIALS AND METHODS

2.1.Study Design

The present investigation was conducted as a retrospective, observational epidemiological study with the objective of assessing malaria trends and *Plasmodium* species distribution in selected districts (Dakshina Kannada and Shivamogga) of Karnataka, India. The study was based on the analysis of laboratory-confirmed malaria cases reported over a continuous five-year period from January 2019 to December 2023. As the study relied exclusively on previously recorded surveillance and laboratory data, no direct patient interaction was involved.

2.2.Study Area

The study was carried out in two geographically and ecologically distinct districts of Karnataka, namely Dakshina Kannada and Shivamogga. Dakshina Kannada is a coastal district situated along the western coast of India bordering the Arabian Sea. The district experiences a warm and humid tropical climate, characterized by heavy monsoonal rainfall and high relative humidity. Rapid urbanization, large-scale construction activities, and migrant labor populations have historically contributed to favourable conditions for mosquito breeding and urban malaria transmission in this region. Previous epidemiological and entomological studies have documented Dakshina Kannada as one of the malaria-prone districts of Karnataka [4, 15].

Shivamogga district is located in the Malnad region of the Western Ghats and exhibits a contrasting ecological profile. The district is characterized by dense forest cover, river systems, undulating terrain, and seasonal rainfall patterns. These environmental features influence mosquito breeding habitats and malaria transmission dynamics differently when compared to coastal districts. Although malaria transmission in Shivamogga has been relatively low in recent years, the presence of suitable ecological conditions necessitates continued epidemiological monitoring [4].

2.3.Data Source and Collection

Secondary data on malaria-positive cases were collected from government health records, laboratory registers, and routine surveillance data maintained at Primary Health Centres (PHCs) across Dakshina Kannada and Shivamogga districts. Only laboratory-confirmed malaria cases were included in the study. Diagnosis was carried out at the respective health facilities using either microscopic examination of peripheral blood smears or rapid diagnostic tests (RDTs), following national malaria diagnostic and surveillance guidelines. The collected records included demographic details, parasitological findings, and geographical information pertaining to the district, taluka, and PHC where the case was reported. All data were anonymized prior to analysis to ensure confidentiality.

2.4.Inclusion and Exclusion Criteria

The study included all malaria cases that were laboratory confirmed and reported between January 2019 and December 2023, provided that the records contained complete demographic and parasitological information. Cases that were clinically suspected but laboratory negative were excluded from the study. Records with missing or incomplete key information were also excluded from analysis.

2.5.Variables Studied

The variables extracted from the records included the year of diagnosis, district, taluka, and PHC of reporting, age and categorized age group (≤50 years and >50 years), gender, and the identified *Plasmodium* species. The parasite species recorded included *Plasmodium vivax*, *Plasmodium falciparum*, and mixed infections.

2.6.Parasitological Diagnosis and Species Identification

Malaria diagnosis and parasite species identification were performed at the respective health facilities using standard microscopic techniques. Peripheral blood samples were collected, and both thick and thin blood smears were prepared. The smears were stained with Giemsa stain and examined under light microscopy. Species identification was based on morphological characteristics of the parasites observed in stained smears, in accordance with the diagnostic criteria recommended by the World Health Organization [16].

2.7.Epidemiological Analysis

Epidemiological analysis was carried out to assess year-wise trends in malaria incidence, district-wise differences in disease burden, and demographic patterns based on age and gender. Spatial distribution of malaria cases was evaluated at the taluka and PHC levels to identify areas with higher disease burden. In addition, the distribution of *Plasmodium* species was analyzed across districts and demographic groups to understand species-specific transmission patterns.

2.8.Incidence Rate:

Incidence rate is an epidemiological measure that quantifies the occurrence of new cases of a disease or health-related event in a defined population during a specified period of observation.

Incidence rate is calculated using the following formula:

$$\text{Incidence Rate} = \frac{\text{New cases in defined population}}{\text{Total population at risk over a specific period of time}} \times 100$$

Shivamogga: Incidence Rate 0.002396 %
Dakshina Kannada: Incidence Rate 0.236068%

2.9.Limitation section:

Only descriptive statistics were applied in this study. The result was summarized using absolute numbers and corresponding percentages.

3. Ethical Considerations

The study was conducted using secondary, anonymized health records obtained from routine surveillance and laboratory data. No personal identifiers of patients were included at any stage of the analysis. As the study involved retrospective analysis of existing records and did not require direct patient involvement, formal informed consent was not required. Confidentiality and ethical standards were strictly maintained throughout the study.

3.1. RESULTS AND DISCUSSION

3.2. Year-wise Trend of Malaria Cases (2019–2023)

A progressive decline in malaria cases was observed in both districts during the five-year study period (figure 1). Dakshina Kannada reported a high burden in 2019, followed by a sharp and continuous decline until 2023. In contrast, Shivamogga consistently reported a low number of cases throughout the study period, with minor fluctuations.

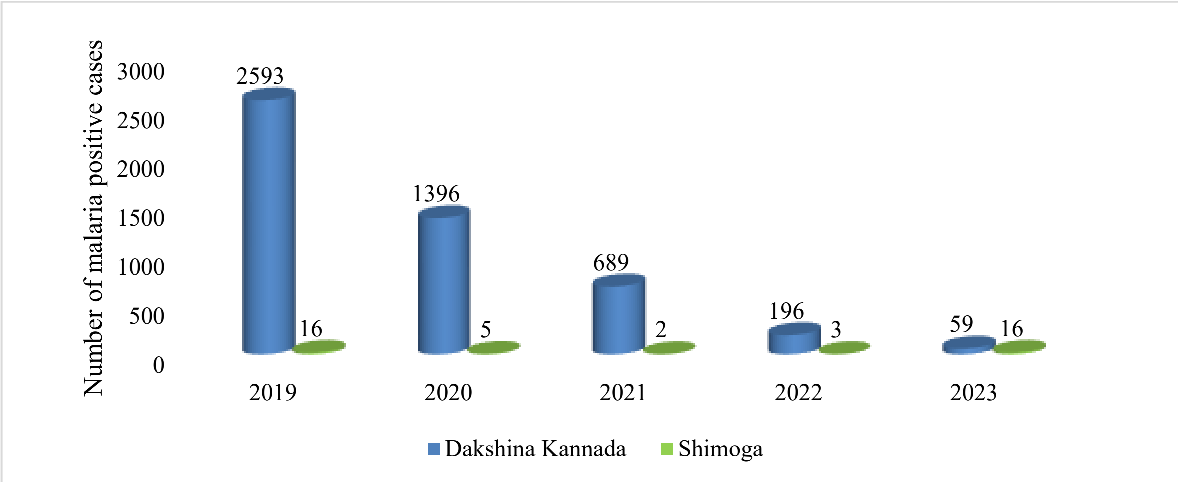

Figure 1: ***Comparison of malaria positive cases by year in Dakshina Kannada and Shimoga***

3.3. District-wise Malaria Burden

Dakshina Kannada contributed overwhelmingly to the total malaria burden, accounting for more than 99% of reported cases, whereas Shivamogga contributed less than 1% of the total cases during the study period.

3.4. Gender-wise Distribution of Malaria Cases

A year-wise gender distribution of malaria cases in Dakshina Kannada district is presented in Table 1 and figure 2. Across all five years of the study period (2019–2023), a consistent male predominance was observed among malaria-positive cases. In 2019, males accounted for 89.0% (2,306 cases) of the total malaria burden, while females contributed 11.0% (287 cases). A similar pattern was noted in subsequent years, with male cases ranging from 89.2% to 96.2% of the annual total.

The highest male predominance was recorded in 2020, where males constituted 96.2% (1,232 cases) of all reported malaria cases, whereas females accounted for only 3.8% (164 cases). In 2021 and 2022, males represented 89.5% and 89.2% of cases, respectively, while females contributed approximately one-tenth of the total cases in each year. In 2023, although the absolute number of cases declined substantially, males continued to dominate, accounting for 91.5% of cases, compared to 8.5% among females. Overall, during the five-year study period, males constituted 93.6% (4,382 cases) of the total malaria cases reported in Dakshina Kannada, whereas females accounted for only 6.4% (551 cases). This persistent male predominance indicates a strong gender-related disparity in malaria occurrence within the study area.

Table 1: Year-wise gender distribution of malaria cases in Dakshina Kannada district (2019–2023)

Year	Gender		Total
	Male	Female	
	Number (%)		
2019	2,306(89.0)	287(11.0)	2,593(100.0)
2020	1,232(96.2)	164(3.8)	1,396(100.0)
2021	615(89.5)	74(10.5)	689(100.0)
2022	175(89.2)	21(10.8)	196(100.0)
2023	54(91.5)	5(8.5)	59(100.0)
Total	**4,382(93.6)**	**551(6.4)**	**4,933(100.0)**

Table 2 presents the year-wise gender distribution of malaria cases reported from Shivamogga district during the study period (2019–2023). Throughout the five-year period, malaria cases were relatively few; however, a consistent predominance of male cases was observed in most years (figure 3). In 2019, males accounted for 75.0% (12 cases) of the total malaria cases, while females contributed 25.0% (4 cases). A similar pattern was observed in 2020, with males representing 80.0% (4 cases) and females accounting for 20.0% (1 case). In 2021, the number of reported cases was minimal, and an equal distribution was observed between males and females, with one case each (50.0%). In 2022, all reported malaria cases were confined to males, accounting for 100% (3 cases), while no female cases were recorded during that year. In 2023, although the total number of cases increased slightly, males continued to predominate, constituting 81.2% (13 cases), compared to 18.8% (3 cases) among females. Overall, during the entire study period, males constituted 78.5% (33 cases) of the total malaria cases in Shivamogga district, whereas females accounted for 21.5% (9 cases). Despite the small number of cases, the data indicate a persistent male predominance in malaria occurrence within the district.

Table 2: Comparison of malaria-positive cases by gender in Shimogga

Year	Gender		Total
	Male	Female	
	Number (%)		
2019	12(75.0)	4(25.0)	16(100.0)
2020	4(80.0)	1(20.0)	5(100.0)
2021	1(50.0)	1(50.0)	2(100.0)
2022	3(100)	0(0)	3(100.0)
2023	13(81.2)	3(18.8)	16(100.0)
Total	**33(78.5)**	**9(21.5)**	**42(100.0)**

3.5. Malaria-positive cases by age group and parasite type in Shivamogga

Table 3 depicts the distribution of malaria-positive cases in Shivamogga district according to age group and *Plasmodium* species during the study period. Among individuals aged ≤50 years, a total of 30 malaria cases were reported. Of these, *Plasmodium vivax* was the predominant species, accounting for 25 cases, while *P. falciparum* was identified in 5 cases. The highest number of cases in this age group was recorded in 2023 (12 cases), followed by 2019 (10 cases). In the >50-year age group, a total of 12 malaria cases were reported. *Plasmodium vivax* remained the predominant species, contributing 11 cases, whereas *P. falciparum* was identified in only one case. Most cases in this age group were reported in 2019 (6 cases) and 2023 (4 cases), while no cases were recorded in 2021. Overall, during the study period, Shivamogga district reported 42 malaria-positive cases, of which *Plasmodium vivax* accounted for 36 cases and *P. falciparum* for 6 cases. The majority of malaria cases in both age groups were caused by *P. vivax*, indicating its predominance across age categories in the district.

Table 3: Malaria-positive cases by age group and parasite type in Shivamogga

Age group (in years)	Year	Parasite type		Total
		PV	PF	
≤50	2019	9	1	10
	2020	4	0	4
	2021	1	1	2
	2022	1	1	2
	2023	10	2	12
Total		**25**	**5**	**30**
> 50	2019	5	1	6
	2020	1	0	1
	2021	0	0	0
	2022	1	0	1
	2023	4	0	4
Total		**11**	**1**	**12**
Grand total		**36**	**6**	**42**

Table 4: Malaria-positive cases by age group and parasite type in Dakshina Kannada

Age group	Year	Parasite type			Total
		Mixed	PF	PV	
≤50	2019	88	145	1976	2209
	2020	28	144	1019	1191
	2021	14	108	457	579
	2022	3	25	147	175
	2023	2	15	33	50
Total		**135**	**437**	**3,632**	**4,204**
>50	2019	34	25	325	384
	2020	5	26	174	205
	2021	3	24	83	110
	2022		2	19	21
	2023	1	3	5	9
Total		**43**	**80**	**606**	**729**
Grand total		**178**	**517**	**4,238**	**4,933**

Table 4 presents the age-wise and parasite-wise distribution of malaria-positive cases in Dakshina Kannada district. Among individuals aged ≤50 years, a total of 4,204 malaria cases were reported during the study period. *Plasmodium vivax* was the predominant species in this age group, accounting for 3,632 cases, followed by *P. falciparum* with 437 cases and mixed infections with 135 cases. The highest number of cases in this age group was recorded in 2019, with 2,209 cases, followed by a gradual decline in subsequent years. In the >50-year age group, a total of 729 malaria cases were reported. Similar to the younger age group, *Plasmodium vivax* was the most common species, contributing 606 cases, followed by *P. falciparum* with 80 cases and mixed infections with 43 cases. The majority of cases in this age group were recorded in 2019 and 2020, with markedly fewer cases reported in later years. Overall, Dakshina Kannada district reported 4,933 malaria-positive cases during the study period. Of these, *Plasmodium vivax* accounted for 4,238 cases, *P. falciparum* for 517 cases, and mixed infections for 178 cases. Across both age groups, *P. vivax* remained the dominant species, and the majority of malaria cases were observed in individuals aged ≤50 years.

4. DISCUSSION

The present study highlights clear age-related and species-specific patterns in malaria transmission across two ecologically distinct districts of Karnataka, namely Dakshina Kannada and Shivamogga. The analysis revealed that the majority of malaria cases in both districts occurred among individuals aged ≤50 years, indicating that the economically productive and more mobile population is disproportionately affected. Similar age-related patterns have been consistently reported in malaria-endemic regions of India, where increased outdoor exposure, occupational mobility, and travel are recognized risk factors for malaria transmission [4, 11].

In Shivamogga district, *Plasmodium vivax* emerged as the predominant parasite species across both age groups, accounting for 36 of the 42 reported malaria cases during 2019–2023, whereas *P. falciparum* contributed only six cases. The majority of infections occurred in individuals aged ≤50 years (30 cases), compared to 12 cases in those aged >50 years. The predominance of *P. vivax* in this district aligns with the established epidemiological pattern observed across most parts of India, where *P. vivax* remains the dominant malaria parasite [17,18]. The ecological characteristics of Shivamogga, located in the Malnad region of the Western Ghats and characterized by dense vegetation, river systems, and favorable vector habitats, may support sustained transmission of *P. vivax*.

The higher number of *P. vivax* cases in the ≤50-year age group in Shivamogga further supports the role of occupational and behavioral exposure in malaria transmission. Individuals in this age group are more likely to engage in outdoor activities such as agriculture, forestry, and travel to endemic areas, increasing their risk of mosquito bites. The relatively lower number of cases in the >50-year age group may reflect reduced mobility, partial immunity acquired over time, or under-exposure to vector habitats, as reported in earlier studies [19]. In contrast, Dakshina Kannada district exhibited a markedly different parasite profile, with *Plasmodium vivax* dominating across both age groups. This finding is consistent with long-term epidemiological trends reported from coastal Karnataka and other parts of southern India, where *P. vivax* has historically been the predominant malaria parasite [4]. The high proportion of *P. vivax* cases in individuals aged ≤50 years underscores the continued vulnerability of the working population, particularly in urban and peri-urban settings.

The presence of *Plasmodium falciparum* and mixed infections in Dakshina Kannada, although in lower proportions compared to *P. vivax*, remains epidemiologically significant. *P. falciparum* is associated with greater clinical severity and increased risk of complications, and its persistence indicates the need for continued surveillance and timely treatment [20, 21]. The decline in mixed infections observed over the study period may reflect improvements in diagnostic accuracy and species-specific treatment protocols, as also noted in previous studies from Karnataka [4].

Age-wise analysis in Dakshina Kannada revealed a substantially higher malaria burden in the ≤50-year age group compared to individuals aged >50 years. Similar observations have been reported in urban malaria settings, where construction activities, migrant labor populations, and occupational exposure contribute significantly to malaria transmission [9]. The lower case burden among older individuals may be attributed to reduced exposure, behavioral factors, or partial immunity acquired through repeated exposure during earlier years. The contrasting parasite distribution between Dakshina Kannada and Shivamogga highlights the influence of ecological, environmental, and vector-related factors on malaria epidemiology. While coastal districts continue to exhibit *P. vivax*-dominant transmission patterns, forested and hilly regions such as Shivamogga also show sustained *P. vivax* transmission. These findings emphasize the importance of region-specific surveillance and species-level diagnosis, particularly in areas approaching malaria elimination. Overall, the study underscores that although malaria incidence has declined substantially, age-related vulnerability and species heterogeneity persist. Continuous monitoring of parasite distribution across age groups is essential to prevent resurgence and to tailor malaria control strategies effectively during the elimination phase.

5. CONCLUSION

The present study provides a comprehensive epidemiological assessment of malaria trends and *Plasmodium* species distribution in Dakshina Kannada and Shivamogga districts of Karnataka over a five-year period. The findings clearly demonstrate a substantial and sustained decline in malaria incidence, particularly in Dakshina Kannada, reflecting the effectiveness of ongoing malaria control and elimination strategies.

Despite the overall reduction in case numbers, the study highlights persistent demographic patterns, with males and individuals aged ≤50 years being disproportionately affected in both districts. These patterns underscore the continued role of occupational exposure, mobility, and behavioral factors in malaria transmission, even during the declining phase of the disease. A notable observation of this study is the distinct difference in *Plasmodium* species distribution between the two districts. While *Plasmodium vivax* remains the dominant species in the coastal district of Dakshina Kannada, Plasmodium vivax also emerged as the predominant parasite in Shivamogga, an ecologically distinct Malnad region. This regional heterogeneity emphasizes the influence of environmental and ecological factors on malaria transmission dynamics. Spatial analysis further revealed that malaria cases in Dakshina Kannada were largely concentrated in urban and peri-urban talukas, highlighting the continued vulnerability of urban settings, particularly construction zones and migrant labor settlements. In contrast, Shivamogga exhibited scattered, low-intensity transmission without sustained clustering. In conclusion, although malaria incidence has declined markedly, the persistence of localized transmission and species heterogeneity necessitates sustained surveillance, species-specific diagnosis, and region-tailored intervention strategies. Continued monitoring at the district and sub-district levels will be crucial to prevent resurgence and to achieve and sustain malaria elimination in Karnataka.

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